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# Bulletin of the International Railway Congress Association

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BULLETIN
OF THE
INTERNATIONAL RAILWAY CONGRESS
ASSOCIATION
(ENGLISH EDITION)

[ 656 .21 (42) & 656 .212 .6 (42) ]

# Station working and equipment on British Railways,

by E. K. WHITTINGHAM,
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There are many excellent volumes which deal with this subject, some of these covering every aspect of organisation, operation, design, equipment, etc. The purpose of this paper is to give up-to-date information on mechanical equipment (excluding road vehicles) employed in British railway stations and depots.

As practices vary from country to country, it would be as well to give some brief comments on British practice and a few definitions of terms to help the reader to understand what follows.

Parcels in Britain are dealt with separately from goods. They are collected and delivered by separate fleets of road vehicles; they are usually sorted, checked and documented at a parcels office in the passenger station; and on the rail journey are carried on passenger or parcels trains. Because parcels are afforded a superior transit they are charged at higher rates than goods traffic.

Goods are conveyed by goods train in mixed or « full » loads. The mixed loads are called « sundries » or « less than wagon load traffic ». The « full » loads are comprised of consignments greater than a ton in weight. If the firm's sending or receiving point is rail connected it is called a « Private Siding » and the goods do not pass through a goods station. All « sundries » and « full loads » which have to begin or complete their journey by road are dealt with in goods stations. « Sundries », because they have to be sorted and mixed with other goods for the same destination or consignee, are more conveniently dealt with in « goods sheds ». « Full loads » are usually handled outside the shed in the « yard ».

Some goods are held in store by the railway, either before or after rail transit. These are stored in a « warehouse » or perhaps in a part of the « goods shed » allocated to that purpose.

It is the practice in Britain for the railways to collect and deliver « sundries » by their own cartage units, or by cartage agents working under contract to the railways. With « full loads » the cartage may be performed by the trader himself, or by an agent of his, or he may ask the railway to do it for him.

At many goods terminals certain wa-

gon movements are performed by capstan or shunting tractor instead of by shunting locomotive. In most cases the control of these subsidiary movements is the responsibility of the goods agent and is therefore a terminal (commercial) matter as distinct from normal shunting which is done by the operating department.

The ice cream is packed in small containers weighing about 80-lb. when full. Twenty-two such containers are loaded by the manufacturer on a large pallet. Three such pallets are carried on one cartage vehicle (see fig. 1). On arrival at the station a fork truck unloads the three loaded pallets in less than three minutes and reloads the road vehicle with

Fig. 1. — Fork truck unloading cartage vehicle carrying palletised ice cream containers.

## PARCELS.

The volume of parcels handled at any one station is rarely great enough to justify the economical use of fork trucks, conveyors or similar machines. There are exceptions, two examples of which are concerned respectively with the handling of ice cream containers at a large depot in London, and the method of dealing with flowers from the Scilly Isles and Cornwall during the spring season.

three empty pallets, thus liberating it very quickly. Before introduction of this method the average time spent at the station whilst unloading was 35 to 45 minutes. It is thus now possible to perform the cartage operations with less vehicles than previously. The loaded pallets, after being taken off the road vehicle, are placed on the platform by the fork truck and then picked up by pedestrian-controlled pallet truck (see fig. 2) and taken alongside the train.

The containers are transferred from the pallets to the appropriate rail vans, according to destination, as the pallet truck moves along. The introduction of this system enabled a 41 1/2 % increase in traffic to be dealt with in a shorter working day, with less road vehicles, and without adding to the number of staff.

Fig. 2. — Pedestrian controlled pallet truck moving alongside train for loading purposes.

The flower traffic is packed in boxes, some of which are brought to the mainland by ship; others are grown locally. The majority are consigned to Covent Garden Market in London. Two years ago it was decided to experiment in bulk handling methods. Stillages were built, each capable of carrying 60 to 80 boxes of flowers. The traffic was sorted, according to consignee, on to the stillages and these were placed through the doorway of the rail van by fork truck (see fig. 3). A hand pallet truck was used to place each stillage in its final position in the van. On arrival at London the reverse procedure was adopted, and the fork truck placed the loaded stillages on special cartage vehicles which took them to the market. This method proved so successful, both from the traders' and the railway viewpoints, that it is now the regular method of handling this seasonal traffic.

## GOODS.

The introduction of mechanisation in goods terminals has made great progress in recent years, the principal aims being : — to reduce costs in face of rising wages; to minimise fatigue; to obviate damage to traffic; and to improve service to the trader.

### Sheds.

A certain amount of mechanical equipment has always been provided (e. g. fixed manual and power operated cranes) and at large sheds power trucks, or tractors and trailers, have often been employed. Newer types of appliances are now coming into use. For instance, the introduction of comparatively few mobile cranes has enabled large numbers of old fashioned fixed cranes to be taken out with resultant savings in maintenance and reduction of congestion on platforms.

Fig. 3. — Fork truck loading stillage into rail van (Cornish and Scilly Isles flower traffic.)

It is axiomatic that the larger the goods shed the greater is the distribution problem. At a very large shed the contents of 400 inwards wagons may require to be sorted and distributed to perhaps 100 road vehicles for delivery and 400 outwards wagons for further rail transit. Where this sorting element is great, British railways have found it convenient and economical with inwards traffic to interpose a « primary sort » between the wagon discharging and the final operation of loading to road or rail vehicle. The principle of the « primary sort » is much the same as sorting a pack of cards into suits before arranging them in order of face value. Such a system enables traffic to be moved from point to point within the shed in bulk; hence the development of large stillages, pallets or trailers, and the partial disappearance of the traditional hand barrow which carries on average only 1 to 2-cwts. and involves a man to push it whether loaded or empty. The hand barrow is thus being replaced to a large extent by con-

veyors, stillages, internal drays, pallets, etc.

The conveyor is an efficient means of unloading wagons and is well suited to the system of « primary sorting ». In Britain there are several installations where a conveyor (of the slat type) runs level with the platform, a few feet from, and parallel with the siding holding the wagons to be discharged (see fig. 4). bined output of these men passes along the conveyor to its sorting point (see fig. 5) where goods for each of the various sections of the shed are bulked on one carrying unit (stillage or internal dray). These units as they become filled are transported to the appropriate sections for final distribution, and empty units are immediately replaced at the conveyor sorting point.

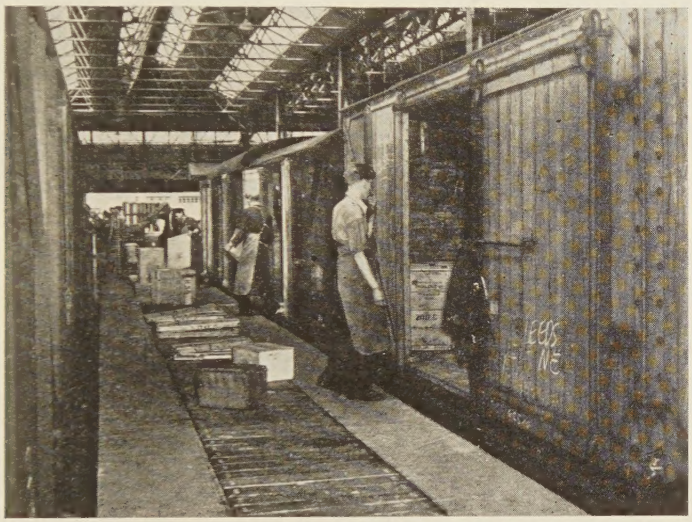


Fig. 4. — Slat type wagon discharging conveyor.

For goods traffic the maximum practicable speed for a conveyor has been found to be 40 feet per minute; some run at only 20 feet per minute. Several wagons can be unloaded on to the conveyor simultaneously, one man working in each wagon, it having been proved that the output of (say) four men working singly is greater than when in pairs, due to the restricting effect of the wagon doorway on men passing in and out. The com-

Another conveyor arrangement is known as the wagon unloading machine (see fig. 6). It is a short rubber-belt conveyor with a free-roller conveyor extension, the whole mounted on wheels to enable the belt to be thrust through the wagon doorway. With such a machine, because the staff remain in the wagon until it has been emptied, it is practicable to work two men inside the wagon. This type of unloading machine,

Fig. 5. — Sorting point at end wagon discharging conveyor.

Fig. 6. — Wagon unloading machine.

working at right angles to the rail track, requires each wagon in turn to be moved towards the unloading point.

The merits of the unloading machine and the slat conveyor have to be carefully considered, but both types have their particular uses, and both enable the principle of primary sorting to be adopt-

Fig. 7. — Elevating truck and loaded stillage.

Fig. 8. — Semi-live stillage with jacking handle.

ed. They each enable goods to be « primary » sorted up to ten or more ways.

Sometimes the « primary sort » is more simple and a conveyor becomes unnecessary for that purpose. In the most simple case where it is only necessary to sort two ways (e. g. town and transhipping) this can often be done manually at or near the wagon side. The underneath the stillage, elevates its carrying platform and so lifts the stillage off the floor and then transports it to the place desired. The truck then lowers the stillage to the floor, withdraws, and proceeds to its next job.

Two types of stillages are used in Britain, known as the « four-legged » and « semi-live ». The latter has two

Fig. 9. — Elevating truck used in conjunction with internal dray.

important aim is to move the goods in bulk on large trucking units. Types of these units which have given satisfactory performance are now described.

The elevating truck and stillage (see fig. 7) forms the basic trucking unit at many of our larger sheds. The stillages are usually 3 to 4 feet wide, 5 to 6 feet long, and stand 12 to 15 inches high above the platform. The trucks are usually battery powered and capable of carrying about 1-ton. The truck runs legs at one end and two wheels at the other. By using a two-wheeled jacking handle it can readily be converted into a four-wheeled trolley, as illustrated (fig. 8), thus enabling it to be manually moved over short distances without an elevating truck.

For use in « deckless » sheds — to be described later — a much larger carrying unit, the internal station dray, has been developed. This has a maximum capacity of 50-cwts. but carries, on average,

about 25-cwts. of sundries. An elevating truck, similar to that used for stillages, runs underneath and picks up the front axle of the dray to form an articulated combination. Two models of truck are employed, one with a high driver's position (fig. 9) to enable him to step on to the dray to handle the traffic, the other with a low driving platform for use when the driver is not required to handle the goods.

An alternative to the stillage and elevating truck system is the pallet and pallet truck, previously described. There are some 20 medium sized sheds in Britain where power pallet trucks have been installed as the principal means of barrowing. Both rider-controlled and pedestrian operated trucks are used, the rider-controlled being for the longer journeys.

Much attention has been given to the design of cranes. We now have several battery-operated mobile cranes of 20 to 25-cwts. capacity (see fig. 10) which will deal with heavy articles in covered vans as well as open wagons. Fork trucks, fitted with crane jib attachments are also being used instead of mobile cranes; they have the advantage of being able to get underneath heavy articles with their forks should they be unsuitable for lifting by slings. There are instances where fork trucks are used instead of mobile cranes in the shed for part of the day and at other times are transferred to the warehouse section for stacking palletised loads.

Fig. 10. — Battery-operated mobile crane loading covered rail van.

### Yards.

There are very few goods yards in Britain which are not provided with a

crane of some sort. At a small wayside depot this would probably be a manual fixed jib crane of 5-tons capacity. Most large stations have power operated cranes ranging from a 6-ton road mobile to a 50-ton electric gantry or goliath crane. Many of the latter are equipped with magnets for handling iron and steel.

A fundamental requirement of a yard crane nowadays, is that it should be capable of dealing with our largest and heaviest containers, i. e. any load up to 6 3/4-tons. Crane manufacturers have collaborated with the railways in developing road mobile cranes equal to this task. In spite of statutory restrictions lorry-mounted cranes have been built, capable of travelling by road from station to station to cope with heavy or bulky articles beyond the capacity of the local installations. These lorry-mounted cranes are also particularly useful for agricultural show work.

Experiments are being made with large fork trucks, both with and without crane attachments, to test their ability to handle containers, sawn timber, steel billets, and similar traffics. It is too early yet to draw conclusions, but the inducement of being able to lift such heavy items without recourse to slinging (as with a crane) makes any such tests well worth while.

The railways have for many years catered for the transport of road vehicles as well as containers, to avoid the transshipment of traffic, by crane, or otherwise. The transfer of road vehicles to and from rail involves the use of expensively constructed loading docks, or high capacity cranes. Research is being made into the possibilities of road vehicles designed to effect the transfer of large containers, tanks, etc. between rail and road without crane power. Certain streams of traffic, passing by rail over long distances between stations not already equipped with adequate cranage facilities, appear to justify this enquiry. The British loading gauge imposes severe restrictions on the carriage of large road vehicles on rail wagons, but there is ample scope for investigation into the best method of transferring the road vehicle body (i. e. container) without its supporting road wheels and chassis, and this course is being vigorously pursued.

Designs have been prepared for mechanised coal depots. Consideration has been given to conveyors, wagon tipplers, elevated tracks and chutes, etc. One of the most successful methods appears to be the use of mobile cranes fitted with grabs for discharging the wagons direct to road vehicle for delivery, to ground for storage, or to hopper for bagging and weighing. A few up-to-date coal merchants have already adopted these methods.

### Private sidings.

Where conditions are suitable, the railways have co-operated with traders in developing schemes for installing rail connections right into the traders' premises. Such schemes, in addition to eliminating cartage and minimising handling, offer inducements to traders in the form of reduced rates.

With private sidings, all handling of traffic is done by the trader, and the need for containers and similar equipment is not so great. However, it is in the field of private siding traffic that

many of the most suitable streams of palletisable goods are to be found.

Considerable investigation has been made, and is still going on, into the most suitable type of rail wagon for the carriage of palletised goods. Now that the probable sizes of British standard pallets are known, and the types of fork or pallet trucks which will deal with them, it has been possible to test loads of palletised traffic in actual transit; find out how they behave in loose-coupled, screw-coupled, and fully fitted trains; what happens during shunting operations in marshalling yards; what interior fittings are necessary (if any) to keep unit loads separated from each other; to what strength the wagon floor must be constructed; the best width of wagon doorway; the best design of ramps to connect platform and wagon; and so on.

Information on these matters is disseminated to all regions and to as many traders as are known to be interested. Whilst the carriage by rail of palletised traffic is still in its infancy, it is true to say that British railways have kept pace with the times and are ready for the increase in palletisation which is sure to follow.

### Warehouses.

The staple commodity of the locality in which a warehouse is situated, generally has an important bearing on the design of the building and the mechanical equipment employed.

Many grain warehouses are provided with sack elevators and chutes, which enable a minimum of staff to cope with the fluctuating seasonal tonnages both in and out of store.

In the West Riding of Yorkshire, wool has to be catered for in large quantities. The wool is in bales varying from 4 to 8-cwt. each. They are dealt with by cranes, hoists, lifts, fork trucks, roller conveyors, rubber belt conveyors and wool piling machines. Probably the most interesting, and certainly one of the most efficient of these is the wool piler (fig. 11), which is an adaptation of the mobile crane, having steel toothed jaws which grip the bale, instead of an ordinary jib. It is capable of stacking the heaviest bales up to five tiers high.

Stacking machines have been found very efficient for dealing with barrels, drums, cases and paper traffic, but it is probable that fork trucks will in many instances take their place.

One warehouse, dealing with large numbers of barrels of beer, has been equipped with a barrel conveyor which carries the barrels to the various floors in a continuous stream, far quicker and more economically than any system of lifts or cranes could do it.

Many warehouses employ stillages for the movement of goods into and out of stock, and to and from the upper and lower floors via lifts.

Finger-tray elevators are installed at some stations for dealing with cases, cartons, bales, etc. This type of elevator has automatic grids which receive or discharge traffic at the various levels, but such an appliance can only deal with a limited variety of packages, and it is doubtful whether any more such machines will be installed, in view of the greater versatility of fork trucks and associated equipment.

On platforms incapable of bearing the

weight of mobile cranes the Monorail (walking jib) crane is frequently employed. This appliance runs on a rail flush with the platform surface and is supported by an overhead track which embodies collector wires to give the electrical energy. The track may be straight or curved to suit requirements and the jib of recent models is made adjustable in height to enable it to enter covered vehicles or lift over the sides of wagons. A crane of this type only requires a gangway 3 feet wide in which to work and the jib radius may be 15 or 20 feet, which enables a considerable area to be served. Capacities are usually in the neighbourhood of 1-ton to 25-cwt.

The most recent developments are mainly in connection with palletisation. Several warehouses have been doubled or trebled in capacity by making greater use of headroom, possible only by the use of pallets and fork trucks. Cases, cartons, bales, sacks and drums all come within the category of suitable traffics and the turnover of stock has been greatly increased with less labour and reduced claims for damage due to handling. There have been several instances where the building of warehouse extensions has been avoided by adopting palletised methods.

Fig. 11 — Battery-operated wool piling machine.

### Wagon moving devices.

Most people are familiar with the alternatives to the shunt engine, used for the movement of wagons within the confines of the goods station. Well over a hundred depots in Britain are equipped with capstans. Many of these are used in association with turntables or traversers, and, in a few instances, wagon hoists to

take the vehicles to higher or lower levels. Appliances of these types have been in use for over eighty years and the only « improvement » of note, until comparatively recently, was the change (about 1900 to 1910) from hydraulic to electric power when new machines were being installed.

In the last twenty years, a few developments have taken place which are worthy of mention, the aims of which were to save labour, or to reduce overhead costs.

Capstans of the normal fixed-head type generally require two men to operate them, one to wind the rope round the drum and the other to hook on to the wagon and apply brakes. It is usual for these capstanmen to be employed solely for that purpose, and while they are working, the handling staff, especially the wagon discharging gangs, have to wait until the wagon movement ceases. It was felt that a capstan should be designed which could be operated by the handling staff, and this led to the design of the free-head capstan which has one end of wire rope permanently attached to the capstan drum, and the rest of the rope is normally wound round it. The operator wishing to use the capstan moves a clutch which releases the drum (hence the name free-head) and hauls out as much rope as he requires to hook on to the wagons. The clutch is then engaged and the capstan operated by push-button or other type of remote control from any desired position on the shed platform or elsewhere. If the wagons are moving up an incline they will not require to be braked; if on the level or moving downhill a pre-determined number of hand brakes may be applied which will ensure the wagons stop immediately the capstan ceases to rotate. In this manner, several wagons may be brought to a fixed unloading point, one at a time, merely by pressing a button.

A further development of a remotely controlled capstan is known as the closed-loop capstan, with which an endless wire rope passes round two tension pulleys (which may be 150 to 450 feet apart) alongside the wagon track. At an intermediate point between the tension pulleys, the capstan is installed, and three or four turns of the wire loop are passed round the drum. A hook for attachment to the wagons is connected to the loop and by this means the wagons can be moved forward or backward along the siding for any distance between the two tension pulleys, merely by pressing the appropriate push-button.

A variation of the closed-loop capstan is called the wagon-mule. Instead of the hook attachment, the capstan tows a carriage which runs parallel with the siding. On the carriage is an arm which can be raised electrically to engage the wagon buffer. As the carriage is drawn along by the capstan, the raised arm propels the wagons along the track, until the desired point is reached, when the mule is stopped and the wagons brought to rest. The arm may then be lowered, the carriage moved backwards, and the arm re-engaged with a following wagon.

All three of these developments have considerably reduced the work of capstan staff, enabled the handling staff to control the movement of wagons to suit their requirements and cut down their

waiting time whilst such movements are taking place.

The need to be able to replace a loaded wagon by an empty one quickly and without having to call on a shunt engine (which would have to move over points from one siding to another at least twice, to perform a similar operation) was met by a modern appliance known as the self-propelled traverser with capstan (fig. 12). This machine is essentially a traverser table, mounted on a cross track intersecting two or more (sometimes as many as twenty) sidings. The table carries its own capstan, which enables the traverser to pick up, by-pass, or deposit selected wagons on any siding which it crosses. Where single wagons frequently have to be moved, it is much quicker than a locomotive, requires less staff, and is far less costly to run and maintain. The space required is much less than the system of points and cross-overs which would otherwise be necessary, and the travelling capstan is much less expensive to install than the total number of fixed capstans which would be used if the traverser had no capstan on its table.

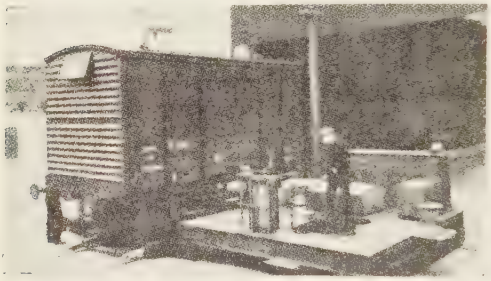


Fig. 12. — 20-ton self propelled wagon traverser with capstan.

These comments would be incomplete unless mention was made of shunting tractors and light shunting units. British railways make good use of numerous tractors, petrol or diesel driven, running on pneumatic tyres and capable of mounting and crossing wagon tracks. They have capacities for moving from 100-tons to 200-tons in a train when working on level ground. Experiments have been made with still lighter, hand steered, one and two-wheeled units in recent years, but results are still rather inconclusive.

**Layouts and structural design.**

Sufficient experience in the modernisation of goods terminals has now been obtained to enable those who plan new depots to specify what is the ideal layout for any combination of physical or commercial conditions. The scope for building new stations under present conditions is limited and, with a few exceptions (due to age or damage by fire or war), planners are more often faced with the problem of adapting existing premises to produce better operational results.

There are two large stations where the planner had a fairly free hand, the principal limitations to his enterprise being the dimensions of the site and the amount of money he could spend; these are Derby St. Mary's (built 1941), and Birmingham, Lawley Street (built 1945). A third new layout is taking shape at Bury St. Edmunds and a fourth at Liverpool, Huskisson, which should be completed early in 1954. Each, in its way constitutes an ideal layout, but, for reasons due to site, volume, nature and

flow of traffic, they are all different and employ mechanical equipment of varying types to a greater or lesser extent. In one respect, however, they are similar; all four layouts embody the principle of loading forwarded sundries traffic direct from road to rail vehicles and, on this account, have no platforms alongside the outwards rail tracks.

The site at Derby (fig. 13) was a square one; the preponderance of traffic was transhipping. This influenced the designer to employ unloading machines rather than conveyors for wagon discharging. Four unloading points were provided, each with an output of 10-tons per hour. Loaded wagons are brought, one at a time, to each machine and the shed is well equipped with wagon moving devices, including fixed-head and closed-loop capstans, wagon mules, winch-hauled and self-propelled traversers. Traffic has to be sorted over 200 ways (160 for transhipping and 50 for delivery) so the « primary sort » at the unloading machines divides the traffic 10 ways (5 for transhipping and 5 for delivery).

At Birmingham (fig. 14) the site was longer and narrower, the preponderating traffic was forwarded sundries, with about 30 % each of received and transhipping sundries. Two slat type conveyors cater for wagon unloading up to about 22 1/2-tons per hour each. The « primary sort » splits the transhipping and the delivered traffic 4 ways each (total of 8) the transhipping being taken by internal drays to the forwarded section, and the town delivered goods on wheeled flats to the lorry loading section.

The third scheme, at Bury St. Edmunds, is a comparatively modest layout with very little mechanisation. The tonnages are small, but the depot serves a large sparsely populated area. The inwards shed has a narrow platform to minimise trucking, and provides sufficient berths for the large number of road vehicles required. Wagons are moved to and from the platform by capstan. The outward shed consists of siding accommodation with cart access under cover of an awning. Modern offices and efficient lighting are provided. The scheme will facilitate the concentration of sundries traffic from surrounding depots, and at the same time provide a new structure in place of one which was so old and dilapitated as to be considered unsafe.

The new Huskisson shed will have only one slat conveyor because the inward sundries are relatively small in volume, there are no transhipping, and the delivered goods have only to be sorted 36 ways. There is thus less need for a « primary sort » and the traffic will pass over a narrow platform direct from conveyor to road vehicle. Alongside the wagon unloading section will be a large warehouse for shipping traffic, where goods will be held pending instructions from the shipping agents.

In each of the three mechanised depots, overhead cranes are provided in the received sundries section, and electric mobile cranes in the forwarded shed (and in the case of Huskisson the warehouse) to cater for the many articles too heavy to manhandle.

The largest goods shed in Britain is at Bristol, Temple Meads (fig. 15). This was originally constructed in 1928 and major alterations to so modern a struc-

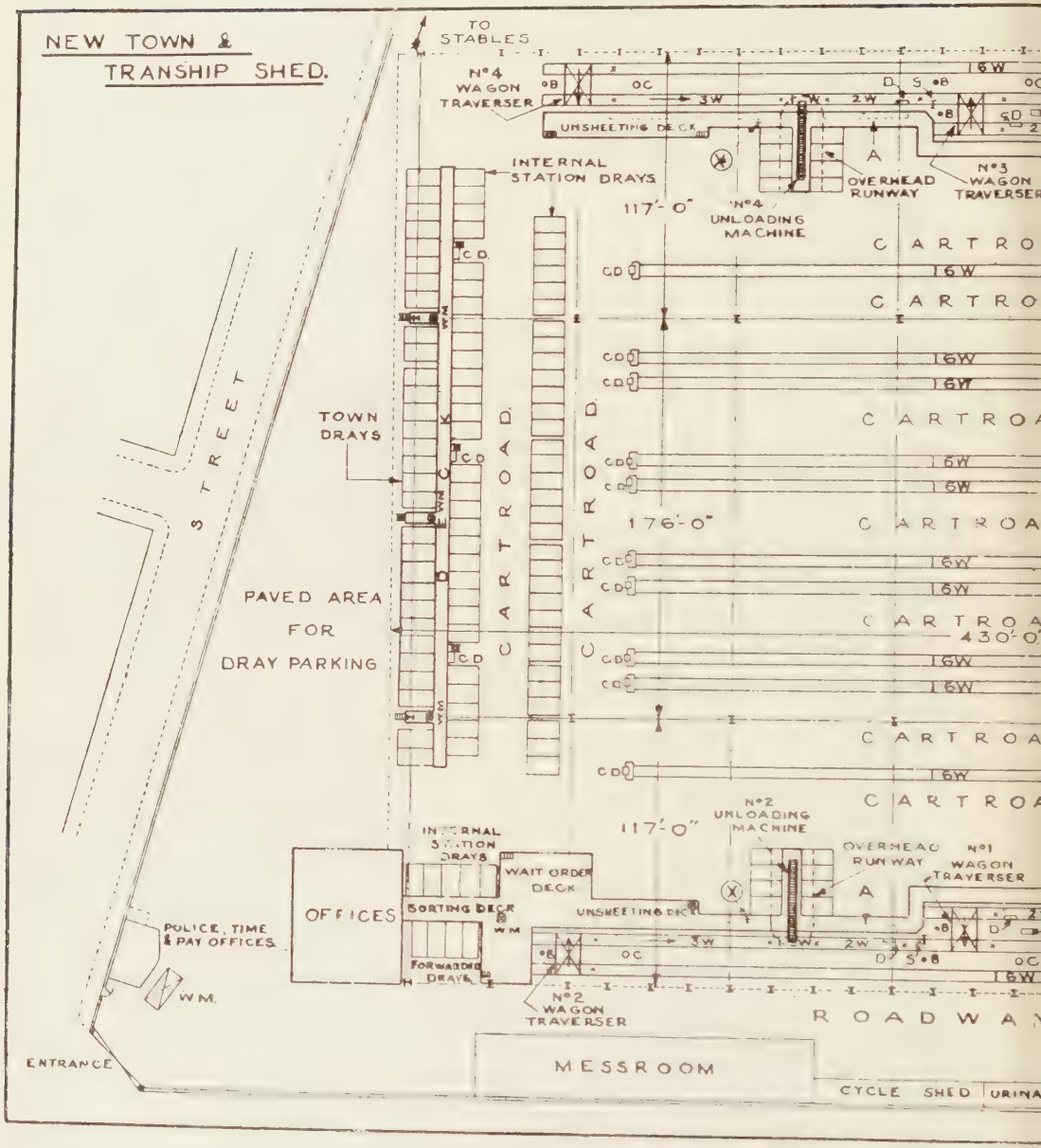
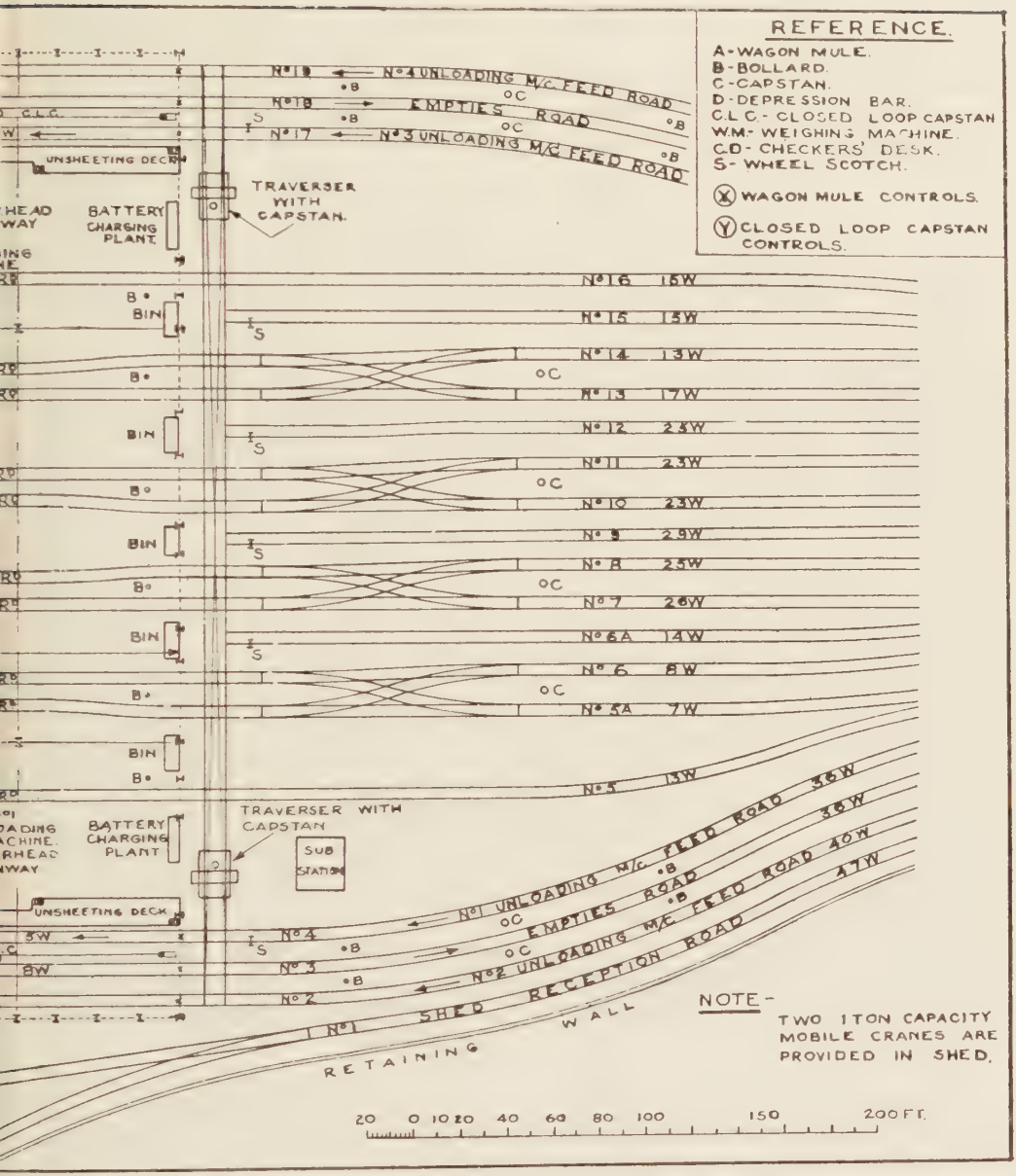



Fig. 13. — Diagram of new tow




shed L.M.R. Derby St. Marys.

ture would have been wasteful. When this shed was modernised in 1951, the original platforms were allowed to remain, and forwarded sundries had therefore to be unloaded from road vehicle to platform before conveying to the wagons. The opportunity was taken to introduce a « primary sort » during this operation

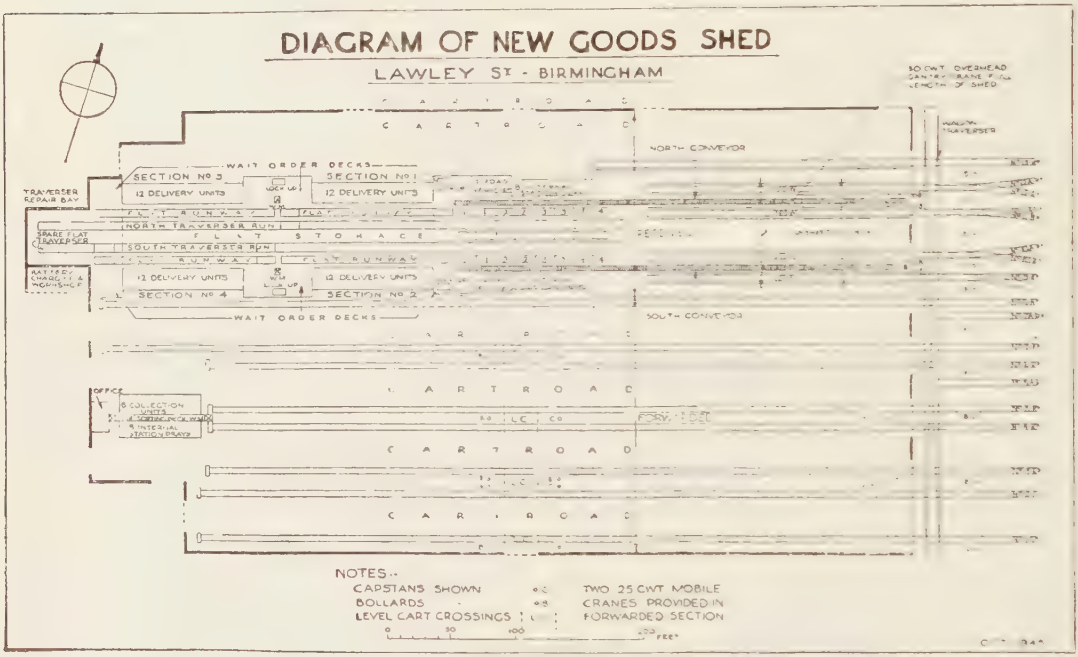



Fig. 14.

and the goods were divided seven ways on to stillages which, when full, were taken by elevating trucks along the outwards wagons and the goods transferred to the appropriate rail vehicle en route.

The received shed layout embodies several new ideas which previously had been considered impracticable from a technical point of view. Two slat conveyors are used for wagon discharging. Transhipments are taken off, immediately after leaving the wagons, at a primary sorting point, and placed on stillages. Town delivery goods remain on the conveyors and pass on to gravity rollers where the packages are temporarily accumulated below platform level. This accumulation on each conveyor is passed forward in alternating streams, via a « junction », on to one main conveyor of the slat type, which rises again to platform level. Here, to follow the profile of the platform edge, it was necessary to introduce a right-angled bend, and this was achieved with a special tapered-slat conveyor with a radius of 16 feet. This in turn passes the traffic on to the final straight slat conveyor running be-

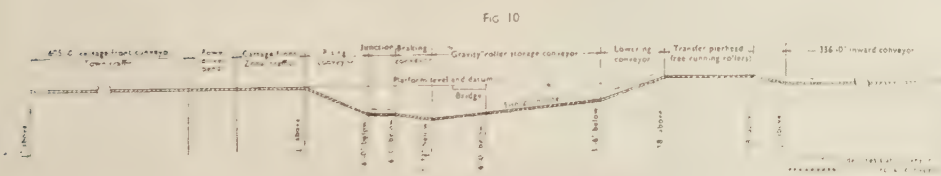
hind the delivery road vehicles. This ingenious arrangement enables the combined output of two conveyors to be amalgamated in one steady stream on one conveyor from which the traffic is loaded direct to road vehicles without any intermediate handling. Mobile cranes, working on the platforms, are used to handle all heavy or awkward items, both forwarded and received.

When all the received traffic has been loaded on to delivery vehicles, the conveyor is again used to deal with the collected traffic which is unloaded to conveyor and sorted from conveyor to stillages for subsequent movement to the outward wagons, as previously described. The conveyor is sufficiently long to permit four separate gangs of men to unload and sort the forwarded sundries, which

DIAGRAM 15

PLATFORM-LEVEL PLAN OF TEMPLE MEADS GOODS SHED SHOWING CONVEYORS

FIG 10



DIAGRAMMATIC LONGITUDINAL SECTION OF CONVEYOR SYSTEM

Fig. 15.

factor ensures that the heavy volume of goods is dealt with promptly and catches the first available service to its destination.

The more common problem of the planner, the modernisation of existing layouts, has been thoroughly tackled by all regions of British railways and there are numerous examples of improved facilities of recent introduction in every part of the country.

The introduction of zonal collection and delivery schemes had a tremendous influence on the type of alterations which were undertaken. The principle of the zonal scheme is to concentrate sundries traffic, where possible, at stations having good rail transits, and to close the small depots having an inferior service. The country is divided into zones, each having a main zone station, often surrounded by railheads or sub-railheads for collection and delivery purposes. The practice of sending consignments to a tranship station for reloading to destination has virtually ceased, and traffic which cannot be loaded in a direct wagon is now sent to the appropriate zone station or railhead where it is either delivered direct or trunk motored or sent by rail to the local depot for subsequent delivery.

This change in method has necessitated the provision of more cartage berths at the zone and railhead stations and structural alterations have been carried out accordingly. In many cases, the opportunity was taken to make other adjustments by narrowing the platforms, widening the cartroads, improving lighting and introducing mechanical equipment, all with the objects of reducing handling, trucking, and physical fatigue.

Where the resulting economies justified the expenditure, wagon moving devices were installed, old cranes replaced by newer types, conveyors provided, and the movement of goods in bulk on stillages, internal drays, or pallets made possible.

Representatives from each region meet every month to exchange views, discuss problems, attend demonstrations of new mechanical appliances, and arrange experiments with novel methods and equipment. Reports are made on such topics as Shed Layout, Warehouse Design, Cranes, Wagon Moving Devices, Palletisation, etc., and these are circulated to all commercial officers to assist them in tackling the problem of modernisation.

The financial situation has prevented many ambitious schemes from being implemented, and the tendency nowadays is to introduce portable equipment rather than spend capital on permanent structural and mechanical installations. Thus, until conveyors, overhead cranes, deckless sheds, capstans and traversers can be provided, the greatest use is made of mobile cranes, elevating trucks and stillages, pallet trucks and pallets, and similar mobile equipment. This temporary measure has several advantages, for example :—

1. The adventurous planner can make experiments at one station with the comforting knowledge that should the venture fail the equipment can be sent elsewhere where the results may prove more satisfactory.

2. The use of pallets and pallet trucks for domestic purposes enables the rail-

ways to prepare for the time when traders will offer their traffic on pallets for rail transit in larger quantities.

3. An immediate saving can be made with the portable equipment instead of waiting for the time when full mechanisation becomes practicable.

4. The possibility that conditions may change due to local rises or falls of traffic, etc., is better catered for by mobile equipment than by fixed installations.

The present position with regard to modernisation of goods sheds, is that the majority of the small and medium sized stations have been examined and schemes for improvement either carried out or authorised; a few of the large sheds have been mechanised and most of the remainder are being actively considered, or have schemes prepared and awaiting implementation.

The planner's job, however, is not as straightforward as might be imagined from the foregoing remarks. Britain has the oldest railways in the world, and many of our depots have done well over 100 years' service. The old fashioned wooden platforms, of which there are very many, are ill suited for bearing the weight of heavy machines like fork trucks, mobile cranes, or even elevating trucks. Roadways and cart berths which at one time adequately provided for the old horse vehicle are now proving cramped accommodation for the modern motor. Warehouse floors and lifts which were at one time strong enough for most purposes are proving too flimsy for palletised methods of operation. In spite of these handicaps, much has been done, and the tempo of modernisation and mechanisation is increasing.

[ 625 .113 ]

# Accelerations on turnouts taken at high speeds.

## Considerations on their layouts,

by J. CHAPPELLET,

Ingénieur honoraire de la Société Nationale des Chemins de fer français (Service central de la Voie de la Région Nord).

The *Revue Générale des Chemins de Fer* of January 1949 gives particulars of the trials of running over at 120 km (74 miles)/h a 0.03 tangent turnout and a 0.05 tangent turnout at 100 km (62 miles)/h on the French National Railways. It seemed to us it would be of interest to compare these tests with those we mentioned in the article we published in the October 1939, *Bulletin of the International Railway Congress Association*, dealing with the passage over a curve of 2 000 m (100 chains) radius with no cant nor parabolic entry at 120 (74 miles), 110 (68 miles) and 100 km (62 miles)/h, through a symmetrical turnout, through the turnout with parabolic entry of the junction at Longueau, through the old turnout with circular entry of 736 m (36.8 chains) radius at the same junction replaced by the parabolic entry mentioned above.

**Curve of 2 000 m radius, no cant, no parabolic entry. V = 110 km/h** (diagram No. 1).

The acceleration (1) at the entry on the curve equals 0.16 *g*. This acceleration not being felt by a passenger standing up over the bogie in the corridor of a coach is therefore negligible. We conclude therefrom that any acceleration at the entry on to a circular curve of about 2 000 m radius has no effect on the

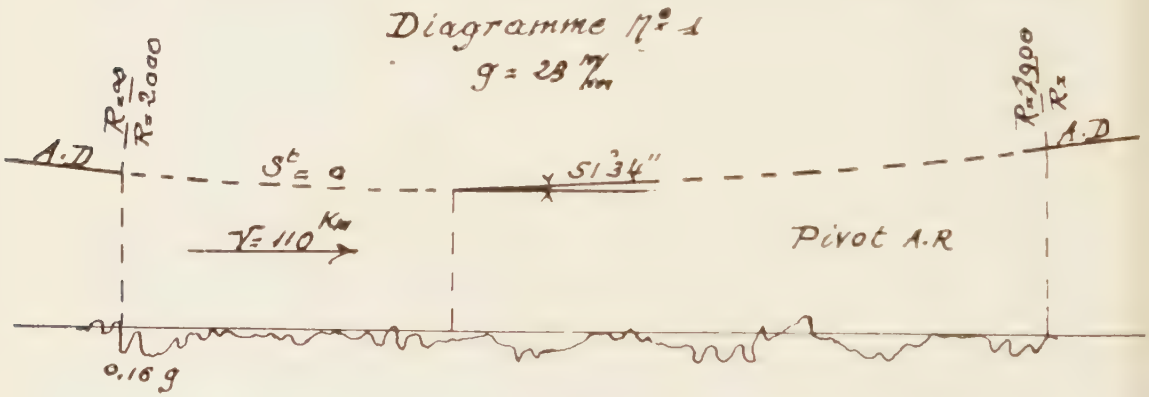



Diagram No. 1.

(1) The accelerations were measured by the quartz piezo-electric accelerometers (Mauzin-Langevin).

passenger's comfort. It is to be noted too that on this diagram an angle of deviation of the points of 51′ 34″ inserted in the curve has not set up any noteworthy acceleration: this is very important when installing turnouts as we shall see later.

**Symmetrical turnout laid with no cant. V = 110 km h** (diagram No. 2).

The angle at the point of the turnout is equal to $\frac{51' 34''}{2}$ and is followed by a straight length of 15 m (49′ 2 1/2″), then by a curve of 885 m (44.25 chains) radius. The acceleration in the angle of deviation

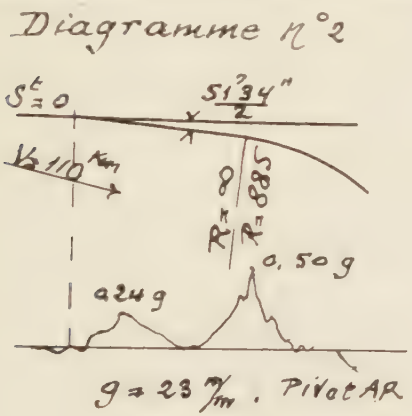



Diagram No. 2.

is equal to 0.24 *g*. Owing to the 15 m straight the diagram shows a fall, then a new acceleration of 0.50 *g* due to entering the 885 m radius curve. Experience has shown that the acceleration, equal to 0.24 *g*, is very acceptable.

**Turnout of tan 0.03. V = 120 km/h** (diagram No. 3).

The angle of deviation is equal to 18′ 57″. The deviation is drawn as an arc of circle of 3 000 m (150 chains) radius which cuts the straight alignment of the direct line at an angle of 18′ 57″. At the summit of the angle of deviation evidently the acceleration due to this angle is to be added to that caused by running on to the 3 000 m radius curve. The diagram shows that the sum of these two accelerations equals 0.36 *g*, which experience shows to be acceptable.

**Turnout of tan 0.05. V = 100 km/h** (diagram No. 4).

The summit of the angle of deviation equal to 25′ is followed by a straight alignment 2.45 m (8′ 0 7/16″) long, then by a curve of 2 000 m radius and 5.45 m (17′ 10 11/16″) of development tangent to a curve of 1 300 m (65 chains) radius. Two successive accelerations, entirely separate from one another equal to 0.23 *g*, are to be noted. The first is set up by the angle of deviation and the second is caused by the entry on to the 1 300 m (65 chains) radius curve. Actually, the ordinate of the chord of the 2 000 m radius curve equals 1.8 mm (0.0708 in.) consequently in fact the 5.45 m of the 2 000 m radius curve might be confounded with a straight alignment. The result is that the summit of the angle of deviation is practically followed by a straight alignment of 2.45 × 5.45 = 7.90 m (25′ 11 1/8″). At the tangent point of the 2 000 m and 1 300 m radii curves, the difference of curvature to be run over is about equal to $\frac{1}{1\,300}$, which explains the second acceleration equal to the first but separated therefrom clearly because of the quasi-straight alignment of 7.90 m length.

**Turnout with parabolic deviation**
(diagrams No. 5*a* to 5*d*).

The summit of the angle of deviation equal to 45′ is followed by a parabolic connection of curvature $\frac{1}{\infty} = 0$ at the origin, which practically is equivalent to a straight alignment 15 m long approximately. The maximum acceleration of the diagram lying to the right of the angle of deviation is evidently caused by this latter.

With V = 100 km h, cant = 40 mm (1.574 in.) the acceleration equals 0.28 *g*.

When V = 100 km/h, cant = 59 mm (2.322 in.) the acceleration equals 0.26 *g*.

When V = 110 km/h, cant = 59 mm, the acceleration equals 0.35 *g*.

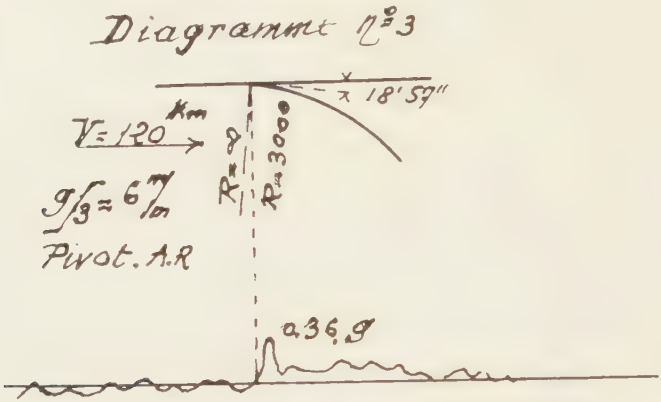



Diagram No. 3.

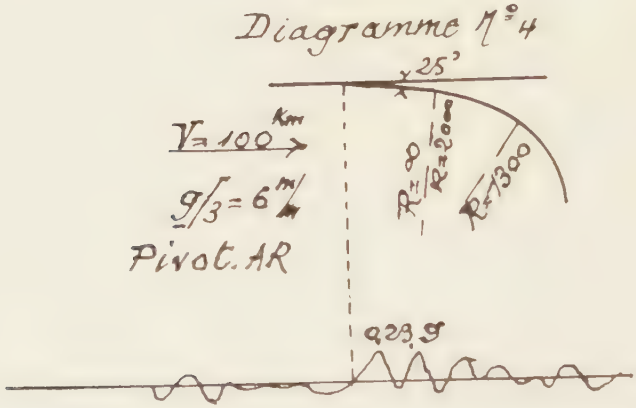



Diagram No. 4.

When V = 120 km h, cant = 59 mm, the acceleration is equal to 0.37 *g*.

In order to know the intrinsic acceleration due to the angle of deviation, it is necessary to add to the acceleration of the above table the reduction produced

by the cant, that is to say to add 0.03 *g* to the first acceleration and 0.04 *g* to the three others.

**Turnout with circular deviation 736 m (36.8 chains) radius. V = 100 km/h** (diagram No. 6).

The summit of the angle of deviation of 51′ 34″ is followed by a short straight alignment 4.00 m (13′ 1 1/2″) long and then by a curve of 736 m radius. The points are laid with a cant of 90 mm (3.543 in.). We observe a first acceleration of 0.36 *g* evidently caused by the angle of deviation followed by the commencement of a drop due to the short 4 m straight, and rapidly interrupted by the acceleration on entering the curve of 736 m radius, which follows the former to attain a total acceleration equal to 0.61 *g*.

In order to know the intrinsic value of these accelerations, we must take into account the 90 mm cant and add 0.06 *g* to the accelerations indicated on the diagram.

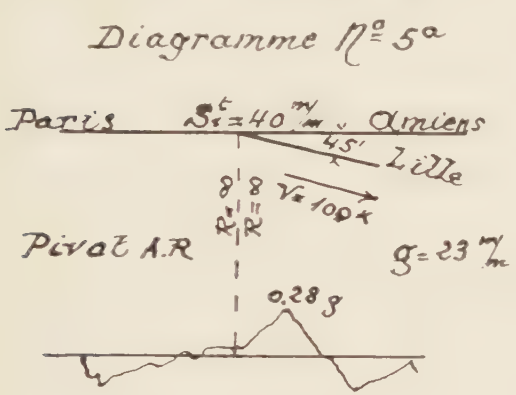



Diagram No. 5*a*.

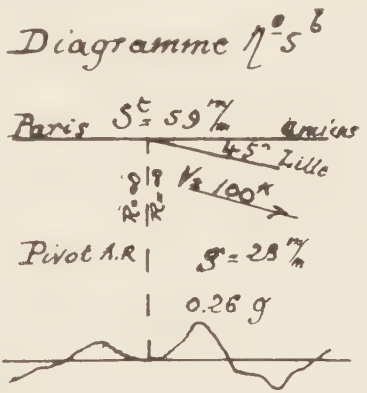



Diagram No. 5*b*.

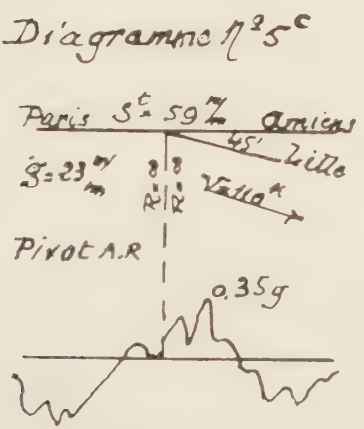



Diagram No. 5*c*.

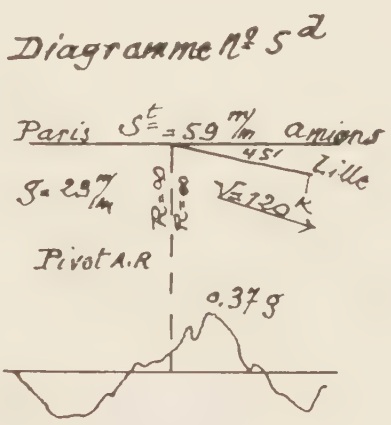



Diagram No. 5*d*.

**Comparison of the diagrams, considerations on the layout of the turnouts.**

The examination of these diagrams shows :

1°) a reasonably satisfactory concordance between the measurements of the acceleration in the deviation angles at the various speeds, it being understood that the value of the acceleration in a deviation angle depends within a few hundred parts of $g$ upon the way the wheel strikes the angle, that is to say, on the obliquity of the axle in the track;

(32′ 9 3/4″) to 15 m (49′ 2 1/2″) in length between the summit of a small angle of deviation: 25′ for example: and the tangent point of the 3 000 m (150 chains) radius curve of the deviation for example, at the speed of 120 km/h a diagram is obtained with clearly separated two accelerations respectively equal to about 0.26 $g$ and 0.14 $g$. As a result, this diagram would indicate the absence of any disturbing acceleration;

4°) that if (see diagram No. 3) in front of the turnout we draw a curve of

Diagramme N° 6

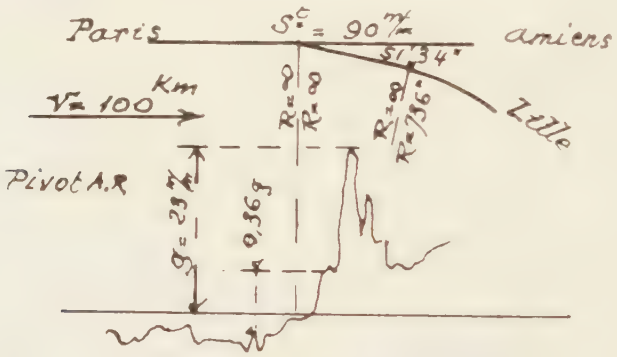



Diagram No. 6.

2°) that the acceleration in the angles of deviation equal to 45′ and 54′ is less than that at the entry on to a curve of average radius (736 m and 885 m) (diagrams Nos. 2 and 6);

3°) that care must be taken to see that the summit of an angle of deviation does not coincide with the entry on to the deviation curve as the two accelerations set up add themselves together (diagrams Nos. 3 and 6). Consequently, by inserting a straight alignment of 10 m

3 000 m radius tangent to the straight alignment of the through road at the joint of the switch or at the summit of the angle of deviation, the angle of deviation of 18′ being inscribed in a curve of 3 000 m radius, the acceleration in this angle becomes negligible (diagram No. 1). Furthermore, at the summit of the angle of deviation, the tangent point of the 3 000 m radius curve and the straight alignment of the branch, the difference of curvature to be run over

being equal to $\frac{1}{3\,000}$ the resulting acceleration less than 0.16 $g$ is still negligible (diagram No. 1).

This remark reminds us that in the above quoted article of the *International Railway Congress Bulletin* for October 1939, we stated that in order to run through the turnout of a junction with a circular curve of about 800 m (40 chains) radius, it was sufficient, for example, to have a curve of the same radius in front of the turnout or a suitable parabolic transition. This solution obviously only applies in the case when the speed is restricted on the through line, owing to running through the curve $\frac{1}{800}$ at the tangent point of the straight section and the 800 m radius curve.

Mr. WATEL, Chief Engineer of the Maintenance at the Permanent Way Headquarters of the Nord Region, generalising the problem proposes in the case of the layout of figure 1 to lay in before the turnout a curve the radius $R_3$ of which is given by the formula :

$$\frac{1}{R_3} = \frac{\frac{1}{R_1} + \frac{1}{R_2}}{2};$$

which gives for $R_1 = \infty$ (through line on the straight): $R_3 = 2\,R_2$.

We think that all that is necessary is that the value of $R_3$ satisfies the following conditions:

$$\frac{1}{R_2} - \frac{1}{R_3} \leq \frac{1}{2\,000} \text{ and } \frac{1}{R_1} - \frac{1}{R_3} \leq \frac{1}{2\,000};$$

$\frac{1}{R_2} - \frac{1}{R_3}$ and $\frac{1}{R_1} - \frac{1}{R_3}$, being the differences of curvatures to be run over on the turnout and on the through line respectively.

fig. 1

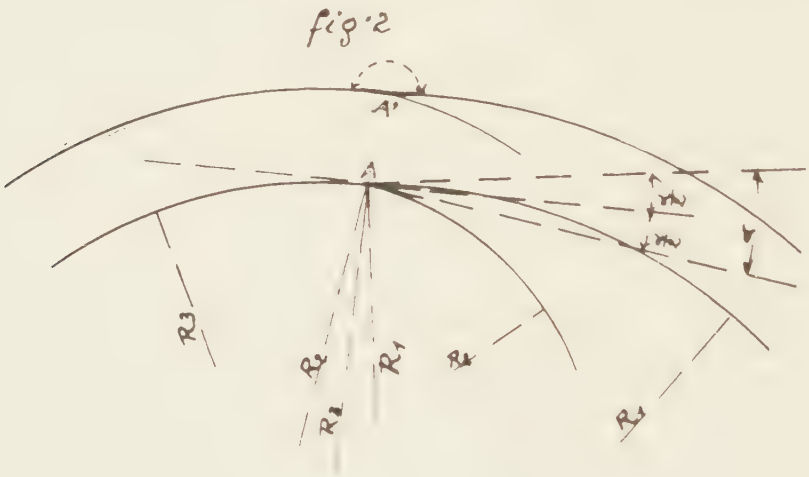
Furthermore, the needs imposed by the location, the relative importance of each direction of the turnout and the provision of the cants, etc., will enable the optimum value of this radius to be determined whilst respecting the equality of the values of the ratios given above. Moreover, when a symmetrical junction cannot be used and to distribute equally two accelerations on the two directions, Mr. WATEL proposed, in the general case, the following very ingenious layout (fig. 2): set down a curve of radius $R_3$ tangentially to the line bisecting the angle of deviation $\alpha$, at the joint of the switch or the summit A of the angle of deviation. As a result, the two curves of radius $R_2$ and $R_3$ cross at A at an angle $\frac{\alpha}{2}$. On the through line, the curve of radius $R_3$ cuts the curve of radius $R_1$ at the point of inflection (A. A') following a « re-entrant angle » $\frac{\alpha}{2}$. To the accelerations due to the change of direction those due to the rotation of the vehicle about a vertical axis being suddenly stopped on running on to the curve of radius $R_1$ must be added. The radius $R_3$ however being very great the latter accelerations, a priori, are negligible. The value of the

radius $R_3$ is given by the formula :

$$\frac{1}{R_3} = \frac{\frac{1}{R_1} + \frac{1}{R_2}}{2};$$

the differences of curvatures to be run over on each branch : $\frac{1}{R_1} - \frac{1}{R_3}$ and $\frac{1}{R_2} - \frac{1}{R_3}$ not being allowed to exceed $\frac{1}{2\,000}$.

To take a concrete example and making




$\alpha = 18'$, $R_1 = \infty$, $R_2 = 3\,000$, wet get: $\frac{\alpha}{2} = 9'$, $R_3 = 2\,R_2 = 2 \times 3\,000 = 6\,000$ m.

The difference of curvature to be run over on each branch is equal to:

$$\frac{1}{3\,000} - \frac{1}{6\,000} = \frac{1}{6\,000} - \frac{1}{\infty} = \frac{1}{6\,000};$$

the maximum resulting acceleration at the speed of 120 km/h will be notably less than 0.16 *g* (diagram No. 1). As to the acceleration engendered by the angle of deviation of 9′, it will be much below 0.24 *g*. As these accelerations have no ill effects on the comfort of the passengers, this layout should give excellent results, and should we think be given consideration. Obviously, all the above presupposes a suitable bending of the stock rail. Mr. WATEL has produced what he calls a « quasi symmetric » junction which evidently lacks the advantage of the symmetrical junction, but when this cannot be used has great interest;

5°) that it is possible to propose to layout a 0.05 tangent turnout following a 2 000 m radius curve of about 20 m (65′ 7 3/8″) developed length, cutting the straight alignment at an angled deviation of 20′, and a curve of about 1 200 m (60 chains) radius tangent to the former. The diagram of accelerations of this deviation run over at 100 km/h will have a maximum acceleration of about 0.30 *g* due to the angle of deviation and to the entry on to the curve of 2 000 m radius, then clearly separated from this latter, a

second acceleration less than 0.16 $g$ and so negligible due to running over the difference of curvature equal to

$$\frac{1}{1\,200} - \frac{1}{2\,000} = \frac{1}{3\,000}.$$

This very acceptable diagram would become almost perfect by laying in in front of the turnout a curve of radius $R_3 \geq 2\,000$;

6°) the deviation of a 0.05 tangent turnout laid out with a parabolic arc connecting the ends of the curvatures equal respectively to $\frac{1}{3\,000}$ and $\frac{1}{936}$ (1), with an angle of deviation equal to 25′ could be run over at 120 km/h with an acceleration at the angle of deviation equal to about 0.36 $g$. The diagram of the acceleration of this turnout would be equivalent to diagram No. 3, but the length of the turnout between points would only be 55 m (180′ 5 3/8″). The acceleration in the angle of deviation could be reduced appreciably by laying as mentioned above in front of the parabolic connecting arc a curve of 3 000 m (150 chains) radius;

7°) it would be useful to build on a line out of service a series of separate points which could be run over at high speed. The diagrams of the accelerations recorded would enable the different designing officers to design permanent way apparatus and to get out track layouts in a rational manner. The said line not in use would be the test plant for the Permanent Way Department.

It seems to us to be well when ending this study to report that during the high speed run through the turnouts with parabolic deviation at Longueau, the accelerations measured when the points were taken trailing were greater than when run over facing, all other conditions the same.

(1) For the calculation of the layout of this junction see *Bulletin of the International Railway Congress Association*, September 1930, « Turnouts with parabolic deviation », by J. Chappellet.

[ 625 .212 (44) & 625 .42 (44) ]

# Trials of a coach on pneumatic tyres on the Paris Metropolitan Railway.

## Experiments on the shuttle service line « Porte des Lilas-Pré-Saint-Gervais »,

by Ulysse LAMALLE,

Ingénieur civil des mines A.I.Lg. Directeur général honoraire de la Société Nationale des Chemins de fer belges. Professeur émérite du Cours d'exploitation des Chemins de fer à l'Université de Louvain.

(*Science et Technique*, nos. 3/4 and 5/6 of 1952.)

SUMMARY.

Introduction.

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1. Body.
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3. Running gear.
4. Method of guiding.
5. Motors.
6. Bogie.
7. Transmission.
8. Supply.

Chapter II. — Track.

1. Longitudinal timbers.
2. Guiding rails.
3. Accelerations. — Decelerations.

Chapter III. — Braking.

— Rheostatic brake.

— Compressed air brakes :
automatic;
direct;
emergency.

— Parking brake.

Chapter IV. — Speed control.

Chapter V. — Signalling.

Chapter VI. — Conclusion.

## INTRODUCTION.

In *Science et Technique*, No. 1, 1949, we described the rake of coaches *on pneumatic tyres* put into service by the French National Railways on the Paris-Strasbourg service.

Now in its turn the Paris Metropolitan Railway is carrying out tests with a coach on pneumatics.

These two applications have great differences.

Between Paris and Strasbourg, the pneumatics run *on the rails* with the resulting very narrow running surface and to get a reasonable life the load each tyre carries has to be only 1 t *per wheel*.

On the Metropolitan, the running surface is provided by *longitudinal timbers of oak* laid alongside and outside the steel rails which have been retained for the time being. Thanks to the width of this special track the tyres can be those used under heavy goods motor lorries and the load per tyre increased to 4 t *per wheel*, with for an equal tare weight of the coach, a reduction in the number of axles.

Let us consider one of the Paris-Strasbourg coaches : it weighs 21 t loaded, carries 64 passengers and although ultra light in construction compared with standard stock owing to the limitations to 1 t for wheel maximum, it has to be carried on two bogies each with five axles, i. e. it is carried on 20 wheels. The Metropolitan coach, on the other hand, carries 154 passengers (seated and standing), it weighs 34 t loaded, so that it requires with the

Fig. 1.

load of at least 4 t per wheel, only two four-wheeled bogies or 8 wheels.

## CHAPTER 1.

## DESCRIPTION.

### 1. BODY.

The coach on pneumatic tyres is an *electric motor coach* carried on two bogies : the body is 15 m (49′ 2 1 2″) long and 2.40 m (7′ 10 1/2″) wide (fig. 1 to 3).

The body carries two electric traction motors supplied with 600 V direct current. Each motor drives the two axles of one bogie.

| | | |
|---|---|---|
| Weight empty . . . | | 19 500 kg (43 000 lbs.) |
| Passengers sitting on *fixed* seats . . | 24 | |
| Passengers standing. | 130 | |
| | | 154 passengers |
| Exceptional overloads : | | |
| Standing passengers. | 210 | |
| Seated passengers . | 24 | |
| | | 234 passengers |
| Tip-up seats for use in rush hours . . | 24 | |

### 2. ARRANGEMENT.

The coach is fitted with 8 loud speakers — one per door — which give out :

— *at a stop,* the warning « About to leave, stand clear of doors if you please »;

— *between stations,* the warning of the approaching stop with connections if any.

These latter indications are controlled *automatically* by the passage of the coach past equipment on the track between stations; the notice is then given by the eight loud speakers.

*Lighting.*

The lighting is by 20 fluorescent tubes each of 20 W, carried along the sides of the clerestory.

### 3. RUNNING GEAR.

The vehicles run on the eight carrying wheels fitted with pneumatic tyres 1.050 m (3′ 5 11/32″) in diameter light, and each normally carrying 3 750 kg (8 267 lbs.) (fig. 4 to 6).

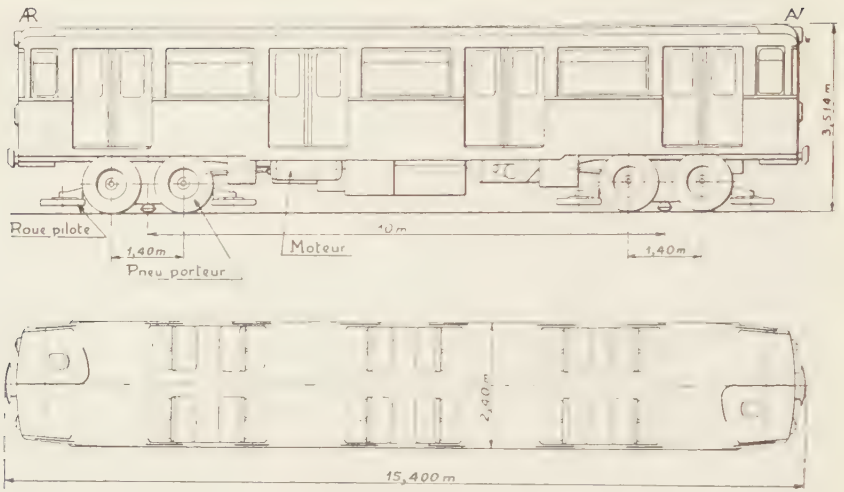



Fig. 2 and 3.

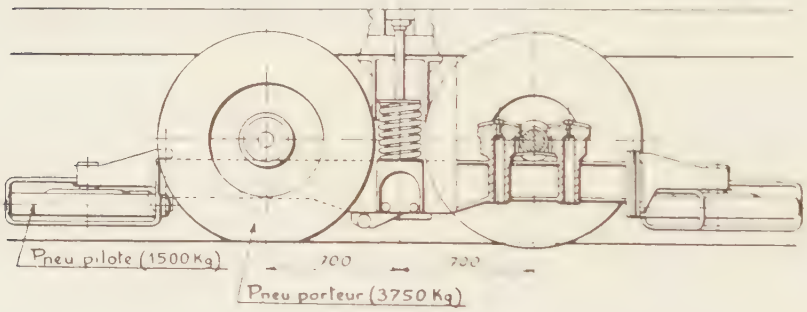



Fig. 4.

*Explanation of French terms:*
Roue pilote = guiding wheel. — Pneu porteur = carrying pneumatic tyre. — Moteur = motor.

These carrying wheels are coupled with the safety wheels in forged steel (fig. 5 and 6) like those normally used on railway i. e. the running surface has a safety flange.

## 4. METHOD OF GUIDING.

The guiding of each bogie is ensured by *four pilot wheels* (fig. 4 and 6) fitted with pneumatic tyres 0.872 m (2′ 10 21/64″) in diameter each able to carry a load of 1 500 kg (3 307 lbs.). These pilot *wheels* are carried on *vertical* shafts off the bogie frame and each is compressed at least 5 cm (1 31/32″) against the *guiding rail.*

## 5. MOTORS.

Each bogie is driven by an electric motor series (tandem) (two armatures on the same shaft), tetrapole, self ventilated, 130 HP.

Each motor is suspended to the body and is fed with D. C. current at 600 V. The normal maximum speed is 3 075 r.p.m. With the reduction of 3/32 and the wheel

diameter, this corresponds to a speed of 56.4 km (35 miles) h.

6. BOGIES.

Each bogie has a frame of H form (fig. 4 to 6) carrying two Durand banjo axles with worm gear and differentials, which drive the axles.

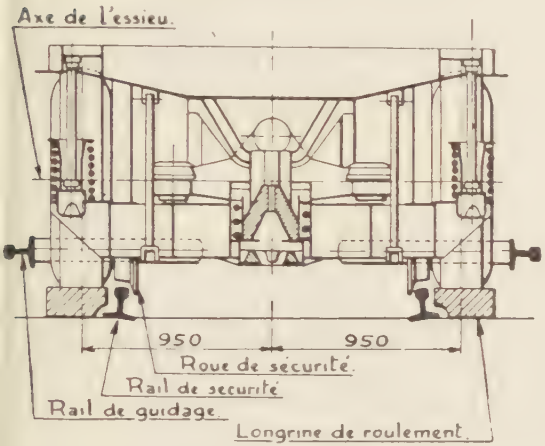



Fig. 5.

*Explanation of French terms:*
Axe de l'essieu = center line of the axle. — Roue de sécurité = safety wheel. — Rail de sécurité = safety rail. — Rail de guidage = guiding rail. — Longrine de roulement = longitudinal timber with running surface.

Each axle consists of two half shafts of the heavy lorry type.

Each half axle carries:

— 1 carrying pneumatic tyre;

— 1 safety wheel;

— 1 drum brake.

The guiding wheels are fastened to each end of the bogie frame in such a way that whilst the relative distance apart can be adjusted the wheel cannot drop on to the track.

A torsion bar carried below the bogie near the pivot is connected to the body by rods and cranks in order to oppose effectively any relative rocking of the body and bogie without interfering with the vertical suspension.

*Deflation of a tyre.*

Should a tyre deflate — whether a carrying or a guiding tyre — the safety wheels come into action with their flanges and running faces without the carriage having to be stopped. Actually, under the worst conditions, the flange is at least 36 mm (1 27/64″) above the rail surface.

Each *carrying* wheel is fitted with a *pressure gauge* with contact so that the guard is given a warning in his compartment if the pressure drop was abnormal. The defective side is also shown by a witness lamp lighting up.

7. TRANSMISSION.

The transmission consists of a longitudinal cardan shaft with splines and is 1.20 m (3′ 11 1/4″) long: it is on the Glaenzer-Spicer system.

This shaft drives another longitudinal shaft which connects the banjos of the two bogies together. The ratio of the worms in these banjos is 3/32.

Each banjo carries a differential between the two half shafts making the axle on which the *carrying* wheels and the *safety* wheels are fitted.

8. FEED CURRENT, HIGH AND LOW TENSION.

The railcar is fed with current as follows:

— 600 V, D. C. for the traction compressor and normal lighting circuits;

— 72 V, D. C. for auxiliary control circuits, emergency lighting and safety lights.

a) *600 V.*

The 600 V, D. C. is picked up either:

1) by *4 shoes* in parallel, which bear on the guiding rails in normal running.

The two positive and negative shoes are placed at the ends of the centre cross member of the bogie frame under the brackets carrying the side equalisers.

The *negative* shoes make certain the

perfect earthing of the mass of the body through the running rails.

The *positive* shoes can be folded back and locked in this latter position :

2) by a *light pantograph* when running over lines in sidings and shops.

The pantograph is operated from the leading driving post.

The 600 V collected by the shoes or the pantograph passes through a two position throw over switch « shoes » or « pantograph », by which each feed can be isolated.

The battery, fitted in a buffer circuit is recharged by the return currents from the normal lighting circuits.

## CHAPTER II.

## RUNNING SURFACE.

### 1. LONGITUDINAL SLEEPERS.

On each side of the existing track a special running surface consisting of *oak longitudinal timbers* 30 cm × 15 cm (11 13/16" × 5 29/32") of suitable lengths

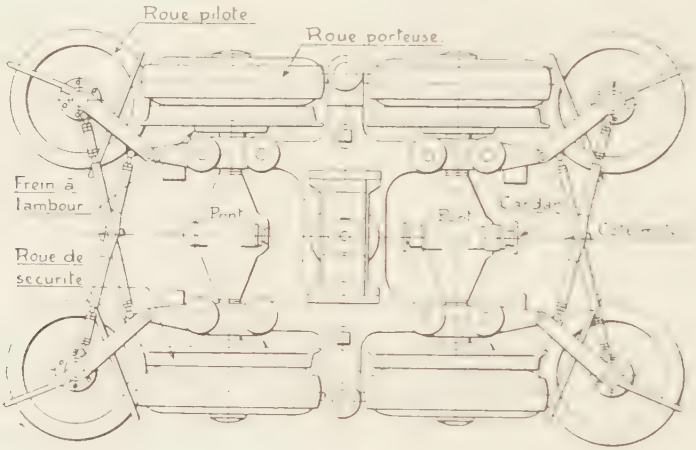



Fig. 6.

*Explanation of French terms :*

Frein à tambour = drum brake. — Pont = banjo. — Cardan = cardan. — Côté moteur = driven side. — Roue pilote = guiding wheel. — Roue porteuse = carrying wheel. — Roue de securite = safety wheel.

The pantograph control is *interlocked* in such a way that it cannot be raised or lowered unless the throw over switch is in the « pantograph » position.

The switch too can only be in the « shoe » position if the pantograph is down.

b) *72 V.*

The 72 V is given by a cadmium-nickel battery of 48 cells of 25 Ah, the voltage variation being at most 58 to 85 V.

have been laid and secured by coach screws to the ends of the wood sleepers, which have been fitted with metal bearing plates (fig. 7).

The consecutive longitudinals have scrafed ends and the joint is of the supported type in that it always rests on a sleeper.

Figure 7 shows that thanks to their having been made the right shape the longitudinals also help to keep the running rails of the safety wheels in place.

2. GUIDING RAILS.

The bogies are guided normally by wheels with a *vertical* axis (pilot wheels) fitted with pneumatic tyres bearing on the *base* of rails arranged with the *under side* parallel with the axis of the track (fig. 7). These are recovered 52 kg (114 lbs.)/m rails.

Blocks of wood coach screwed to the sleeper ends and bolted to the longitudinal timbers by screwed rods and flanges made from channels support the guiding rail.

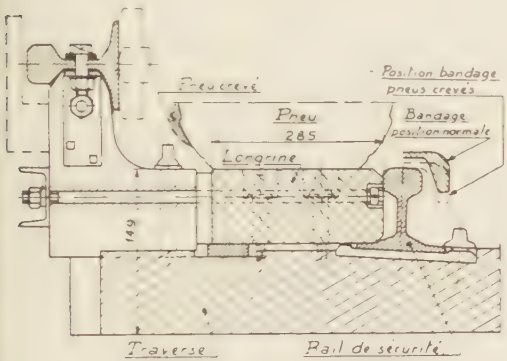



Fig. 7

*Explanation of French terms:*

Pneu crevé = punctured tyre. — Position bandage = position of the tyre. — Bandage position normale = tyre in normal position. — Longrine = longitudinal timber. — Traverse = sleeper. — Rail de sécurité = safety rail.

One block for every third sleeper is provided on the straight and one for every second sleeper on curves.

Moreover, the guiding rails also form the *bars for the current supply*. They are fished mechanically at the joints and a *welded* connection gives the needed electrical continuity for the feed currents.

Between the guiding rail and the blocks an *insulating* washer made of fibre is inserted. The rails and blocks are secured together by stirrups in flat steel and bolts with insulating material in between.

3. ACCELERATIONS. — DECELERATIONS.

The coefficient of adhesion of the pneumatic tyre on wood, concrete or steel is three times that of steel tyres on rails. The result is that accelerations and decelerations can be increased considerably.

The prototype coach when empty or loaded will have:

— an acceleration of 1.2 m/sec²;

— a deceleration of 1.4 m/sec².

Under *emergency braking* the deceleration can be 4 m/sec² as with most automobiles.

This considerable increase in acceleration and deceleration will improve the *commercial* speed; it follows that the quantity of *rolling stock* on pneumatic tyres can be reduced as compared with steel tyred stock.

The *numbers of staff on the trains* can be reduced in the same proportion.

## CHAPTER III.

## BRAKING.

In addition to the *rheostatic* brake the railcar is fitted with a triple equipment of *compressed air brakes*, with eight brake cylinders, one per wheel which can be operated independently:

— either by triple valve and train pipe (as with the *classic automatic brake* (not moderable);

— or by a *direct* acting valve which cannot be *fully discharged* fitted with a *moderable* electro valve;

— or a an *emergency brake*.

The *parking brake* acting on the transmission from each motor completes the brake equipment.

1. RHEOSTATIC BRAKE.

The rheostatic brake is obtained by putting the group of the two motors in parallel on a common resistance which

controls the cam shaft in the series positions.

When using the rheostatic brake at speeds under 10 km (6 miles)/h, the holding power of the motors diminishes progressively.

During this period, a direct air brake (moderable) electrically controlled comes into action automatically to maintain the deceleration at the value of 1.4 m/sec², down to about 3 km (1.84 miles)/h and progressively reduce it to 0.9 m/sec² at the moment of stopping, in order to prevent the wheels from being picked up and thereby reducing the retarding effort.

2. COMPRESSED AIR BRAKE EQUIPMENT.

a) The single stage *compressor* with de-oiler dealer and cooler is driven by a 600 V motor of the silent type, derived from those fitted in modern refrigerators.

b) *Automatic brake.*

This is the classic air brake with the usual « driver's valve », triple valve and auxiliary reservoir.

Four brake cylinders per bogie act directly on the brake drums fitted on the half shafts of the axles.

The handle of the driver's valve, which operates the brake, is coupled to the driving handle so that for all normal running positions (traction or rheostatic braking) the recharging of the auxiliary reservoir is assured (position II of the usual driver's brake valve).

c) *The direct acting brake.*

This direct acting brake, which cannot be completely discharged, is controlled by a moderable electro valve. It acts on the brake drums on the wheels.

It provides the immediate braking during the time to get the electric brake into operation; it is then released by the latter brake coming into action. It again acts to substitute progressively and automatically the air brake for the electric brake during normal stops after the speed has fallen below 10 km/h.

The « deadman » device on the driving handle brings in automatically and without delay the *direct* brake fully, either because of failure of the driver or to hold the vehicle immobile during a stop.

d) *Emergency brake.*

The emergency brake can be applied at six places :

— four inside the vehicle, *at the disposal of the passengers;*

— one inside each driving compartment.

It has a triple function :

— to cut all traction current, if on;

— to apply the *direct* air brake fully;

— to warn the driver by continuously ringing.

The driver can then operate the *rheostatic* brake (deceleration 1.4 m sec²) or the *emergency brake* (deceleration 4 m sec²) if this is absolutely necessary.

3. PARKING BRAKE.

The parking brake is a disc on the traction motor shaft which can be gripped by a band identical with the type used on heavy road lorries.

There is a parking brake per bogie.

One of these brakes by itself can hold the fully loaded vehicle with absolute safety on a down gradient of 40 mm/m (1 in 25).

## CHAPTER IV.

## CONTROLLING THE SPEED OF THE VEHICLE BY FIXED CONDUCTORS INSTALLED IN THE TRACK.

The system subjects the normal control of the speed of the vehicle to an over riding control, which ensures that at each point of the path the speed will be the same as that of a given timetable.

*How is this master control realized?*

The whole length of the track, on the level with the running surface, and between the paths reserved for the pneumatic tyred carrying whels, one *fixed conductor* is laid in two lines each 20 cm (7 7/8") to one side of the centre line of the track and in the form of the greek key pattern (fig. 8 to 10).

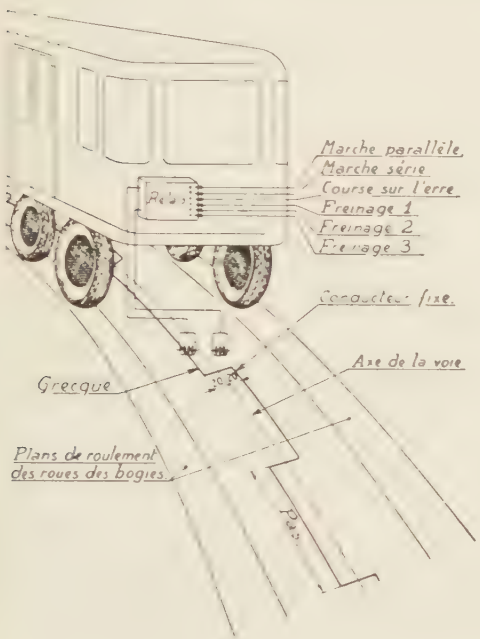



Fig. 8.

*Explanation of French terms:*

Marche parallèle = running in parallel. — Marche série = running in series. — Course sur l'erre = running free. — Freinage = braking. — Conducteur fixe = fixed conductor. — Axe de la voie = centre line of the track. — Grecque = greek key pattern conductor. — Plans de roulement des roues des bogies = running surfaces for the bogie wheels.

This conductor carrying a periodic current influences separately and alternatively *two magneto electric pick ups* carried under one of the bogies of the vehicle.

Two sorts of orders can be transmitted to the pick ups of the coach through the fixed conductor:

a) *general orders.*

These orders of a permanent nature affect safety. For example, there can be no current in the fixed conductor unless the signal protecting the section concerned is « off ».

The absence of current in the fixed conductor at once results in the coach *stopping* without it being possible to release the signal.

Any defect in the fixed circuit acts therefore in the direction of safety;

b) *orders for regulating the speed of the vehicle.*

These are very interesting as they make it possible to get « *automatic running* » as we shall see.

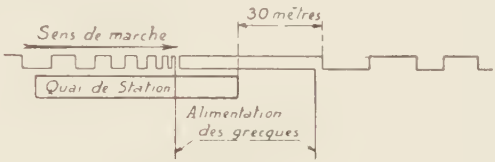



Fig. 9.

*Explanation of French terms:*

Sens de marche = direction of running. — Quai de station = station platform. — Alimentation des grecques = current supply to the greek key pattern conductors.

The fixed conductor arranged in the form of the « greek key line » excites alternatively the two pick ups on the bogie at a frequency depending on the *speed* of the vehicle and the *pitch* of the greek key pattern.

At each point of the track, the *pitch* of the greek key pattern is made proportional to the speed of the vehicle prescribed thereat.

When the vehicle observes this speed the interval between the signals received by the two pick ups is constant.

Let us call this value the *basic interval.*

A series of stepped retard time relays fitted in the coach (fig. 8) notes the frequency of the impulses received by the two pick ups.

The comparison of this frequency with the basic frequency controls (fig. 8) :

1° running in *series* or in *parallel* when the speed of the vehicle is *less* than that laid down in the typical working;

2° the *braking*, to one of the three degrees provided, if the speed of the vehicle exceeds the prescribed speed;

3° *running free* if the speed of the vehicle is *near* the speed laid down.

V, the *real* speed of the vehicle.

If the real speed V of the vehicle is *outside* the space $V_1$ and $V_2$, the apparatus cuts out :

1° when V is *less* than $V_1$ :

the *control of the traction* operating in parallel or in series, depending on the value of the *delay* in receiving the signals emitted by the pick ups relatively to the basic interval;

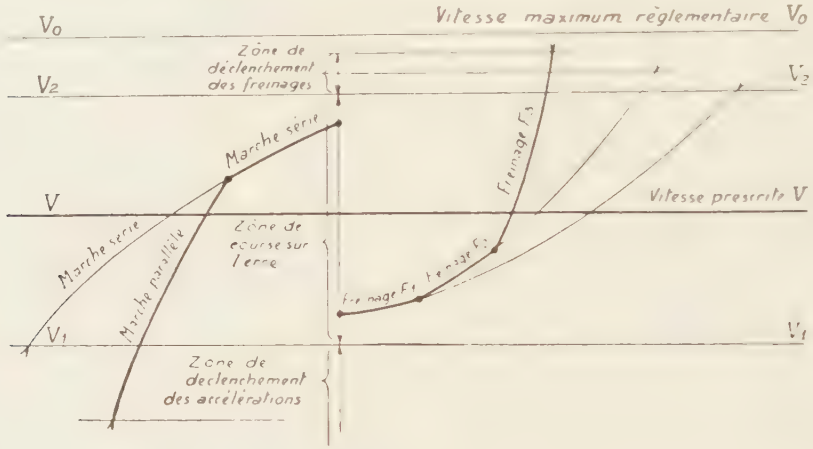



Fig. 10.

*Explanation of French terms :*

Vitesse maximum réglementaire = maximum speed allowed. — Zone de déclenchement des freinages = zone in which brake applied. — Marche série = series running. — Marche parallèle = parallel running. — Zone de course sur l'erre = zone of free running. — Zone de déclenchement des accélérations = zone in which acceleration occurs. — Vitesse prescrite = prescribed speed. — Freinage = braking.

We see therefore that the pitch of the greek key pattern formed by the fixed conductor provides directly at every point of the line the indication of the speed prescribed by the timetable.

Therefore the *principle of working of the automatic running* is as follows :

let V (fig. 10) the speed *laid down* by the timetable at a given point on the track:

$V_2$ and $V_1$, two *adjacent* speeds, one slightly over and one slightly below V;

$V_0$, the *maximum* speed laid down by the regulations for this point;

2° if V is *greater* than $V_2$ :

a *brake application* more or less severe according to the amount of the *advance* in the reception of the signals, emitted by the pick ups relatively to the basic interval.

The system is regulated in such a way that the *maximum* speed $V_0$ of the regulations cannot be exceeded in any case.

Naturally, the whole of the relays fitted in the vehicle (fig. 8) give the same supplies of current as those controlled by the driving handle in the driving compartment, which is out of circuit when running under automatic control.

All the safety devices for manual control remain effective for automatic control.

If anything gets out of order, manual control can be used instead of automatic by simply reversing the control key in the driver's compartment.

It is not possible however to change from manual to automatic control except after a stop at a station and if the starter signal is off.

*To sum up*, the automatic control device relieves the driver from the care of watching the timetable without relieving him of any of his responsibilities as to stopping the vehicle. It forces him to obey the regulations literally.

## CHAPTER V

## SIGNALLING.

The protection of the trains in service is best assured by the *block system*.

In this method of signalling, for each direction of running the line is divided into « sections » and the condition laid down is that « two trains can never be at the same time in one block section ».

On lines with heavy traffic, such as the metropolitan, to accelerate the movement of trains, the block sections are *shortened*.

It then becomes prudent to introduce special arrangements to prevent a train No. 1, accidentally stopped *just in front* of the block signal which protects it, being run into by the following train No. 2, the driver of which had not observed this signal at danger soon enough and so had unintentionally passed it.

One of the methods adopted is that of the *buffer section*.

In this case the equipment is always such that there are always between two trains in motion *a full clear section*. This is the case on the Paris Metropolitan.

With the *automatic* block, the protecting signals are put to all clear or to danger by the trains itself by the electric track circuits (1).

When a section has a train in it, the track circuits are short circuited by the steel wheels and the axles of the vehicles in the section and, thereby, disexciting the relays controlling the placing of the protecting signals to all clear or danger.

By the very nature of the running parts — the pneumatic tyre — the use of the classic method of signalling by track circuits has to be excluded, the tyre acting as an insulator.

Nevertheless it was desired to obtain the usual protection by keeping a clear section between two trains.

For the purpose, the passage of the vehicles is controlled at *each entry* into the section and the vehicles *counted*.

*Block by concordance of counting in and counting out.*

*An emitter carried on one bogie* of the vehicle temporarily excites the relays controlling the track.

Through this emitter passes an alternating current at 50 periods and low voltage produced in the vehicle by a static current undulator.

The *counting* of the vehicles *entering* the section and those *leaving it* to go in to the next section ahead is done by two distinct counters and the control of the protecting signal is obtained by comparing the relative position of these two counters.

At each counting point on the track, the control of the passing vehicles is done by two pick ups $c$ and $c'$ (fig. 11) excited in turn so as not to function unless the vehicle passes in the normal direction of running.

The block system used consists essentially of :

1° *a control device* placed on the track

(1) See *Science et Technique*, No. 9-10, 1951, p. 17 : « Centralised control of the running of trains ».

consisting of two pick ups $c$ and $c'$ and arranged to come into action temporarily as soon as a vehicle runs past this device in the desired direction of running;

2° *a counting selector C,* like the « *step by step* » used in automatic telegraphy.

This selector turns two steps each time the control device of the section *considered* acts;

3° *a subtracting selector D,* identical with the former but turning two steps each time the control device of the section *ahead* registers a passing vehicle;

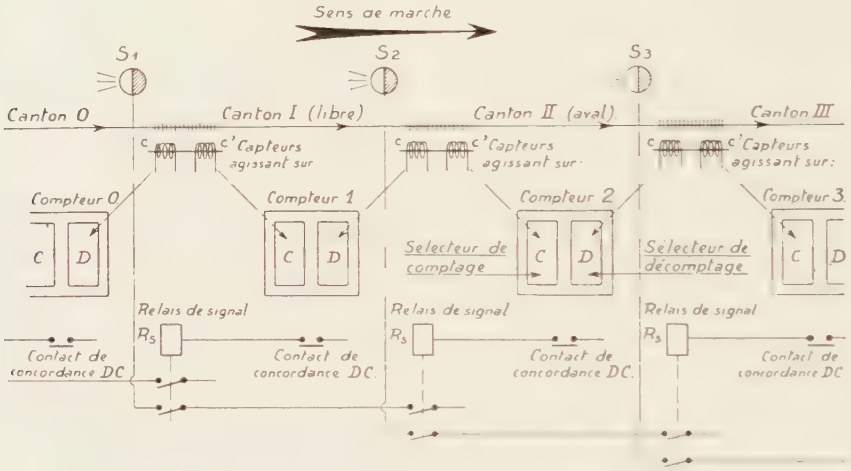



Fig. 11.

*Explanation of French terms:*

Canton = section. — Sens de marche = direction of running. — Canton I (libre) = section 1 (clear). — Canton II (aval) = ahead section II. — Capteurs agissant sur = pick ups acting on. — Compteur = counter. — Sélecteur de comptage = counting selector. — Sélecteur de décomptage = subtracting selector. — Relais de signal = signal relays. — Contact de concordance = concordance contact.

4° *a signal relay R* , the excitation circuit of which is connected in series with the relays of concordance of the two sections on which the signal depends, so as to put this signal to clear as soon as the two *ahead* sections are clear.

*Principe of working.*

Let I the section considered, supposed clear (fig. 11) and II the section ahead.

The starting signal $S_1$ covering the section I is at clear (white light).

If a number of vehicles run into section I the control device excites the counting selector C (counter I), which turns a number of steps proportional to the number of vehicles which entered section I.

The agreement of the counting selector C with the subtracting selector D, *which has in fact not moved,* is then broken, the signal relay $R_S$ is no longer excited and the signal $S_1$ goes to red.

It will not be reexcited until the number of steps the subtracting selector turns will be *identical* with those of the counting selector turned : this is the same as saying *when the number of vehicles leaving section I to enter section II will become equal to the number which previously* entered it. In fact, from this moment, the two selectors occupy again the concording positions. The signal will be restored to line clear (white light)

We see therefore that the block system of concordance of counting and subtracting plays in this signalling system exactly the same role as the relay of the track circuit in the usual block system.

The system lends itself to all combinations of signalling realized with track circuits and especially the *permissive* entry into a block section already occupied.

## CHAPTER VI.

## CONCLUSIONS.

The expected advantages of building Metropolitan vehicles on pneumatic tyres are :

a) *lightness.*

*Steel* tyred wheels under railway vehicles running on rails produce vibrations and shocks which can set up fissurations of the metal of the bogies and bodies. These drawbacks are only avoidable by making the vehicles heavier.

The pneumatic tyre by damping out shocks and vibrations enables the vehicle to be built *much lighter* and the technique applicable to the building of motor buses and cars can be applied to the Metropolitan stock on pneumatic tyres.

As a result the *body* of the prototype coach is made of mild steel sheets 2, 3 and 4 mm (5 64″, 1/8″ and 5 32″) thick folded and spot welded.

The *frame of the bogies* is welded using 4 to 5 mm (5 32″ to 31 64″) steel sheets.

The coach with 4 motor axles, 15 m (49′ 2 1/2″) long, 2.40 m (7′ 10 1/8″) wide, only weighs 19.5 t empty;

b) *rolling stock with all driving axles.*

The coach has 4 banjos driven by two motors suspended to the body. All the axles therefore are driven, which is a matter of great importance for a Metropolitan train *which has to start every 600 m (656 yards);*

c) *acceleration and deceleration.*

The coefficient of adhesion of the pneumatic tyre being three times that of the metal wheel, the acceleration and deceleration can be considerably increased :

acceleration : 1.2 m/sec²;

deceleration : 1.4 m/sec²;

in case of urgent braking to 4 m/sec².

The consequence : an improvement in the commercial speed;

d) *saving in current 30 %.*

In a classic Metropolitan train with *metal wheels* the consumption of current serves :

— on the one hand, to overcome the rolling resistance;

— on the other hand, to produce acceleration that is to set the vehicles in motion to give them the desired speed.

In view of the closeness of the stations, this latter is the more important; it is of the order of 80 %.

With pneumatics, things are different.

The energy consumed to overcome the rolling resistance is *doubled* but that corresponding to the kinetic energy is greatly reduced through the lighter weight of the rolling stock. *In all,* the expected reduction in the consumption of current is taken at 30 %;

e) *silence.*

In the running gear all metal to metal contact having disappeared, the running noises have been practically suppressed;

f) *maintenance of track and bridges.*

The axle loads being substantially reduced the cost of maintaining the track and bridges will be lowered;

g) *gradients.*

For new metropolitan lines the high coefficient of adhesion of the pneumatic tyre will enable the *limiting ramp* of 40 mm/m (1 in 25) generally respected on electrified lines to be exceeded.

It is therefore now possible to imagine a metropolitan system with very steep gradients, which will make it much easier to build them underground.

# Central Railway Centenary Celebrations in Bombay, 16th April, 1953.

## EDITORIAL NOTE.

*In connection with the Centenary Celebrations of the Indian Railways, we are pleased to publish the following descriptive account of the ceremonies which took place in Bombay on the 16th April last, received from Mr. M. S. Sundara, Public Relations Officer of the Central Railway.*

*Further on, in this issue, our readers will find, reproduced in extenso, the very interesting article « Indian Railways 1853-1953 », written by Mr. F. C. Badhwar, Chairman of the Indian Railway Board, which appeared in the Railway Gazette, dated 20th March 1953.*

Thursday, the 16th April, 1953 was a red letter day in the annals of the country and of Bombay, in particular, for it marked the completion of a hundred years of the birth of the first railway in India. Victoria Terminus, popularly known as Bori Bunder, from where the first train in the East steamed out a hundred years ago, was the scene of the Central Railway Centenary Celebrations.

Bori Bunder put on a festive appearance in spite of the surging mass of its daily passengers. Between platform No. 8 and 9 was a magnificent shamiana with a mammoth crowd exceeding six thousand. The elite of Bombay was invited to the function. Ministers of State, High Court Judges, members of the Diplomatic corps, the top ranking officers of the Army, Navy and the Air Force stationed in Bombay, high Government officials, prominent citizens, leading members of the business community and a representative section of Railway staff had assembled to participate in the historic ceremony. Four Bands, two of the Army and one each of the Navy and the St. John Ambulance were in attendance. Colour was lent by three sentries attired with sepoy uniform of 1853 with muskets a 100 years old standing guard at the dais facing the audience.

Punctually at half past four in the evening, the Governor of Bombay, Mr. Bajpai accompanied by Lady Bajpai arrived at platform No. 9 and was received by Mr. H. P. Hira, the General Manager of the Railway. The Governor inspected a guard of honour provided by the Army. After an impressive march past, the Governor was escorted to the beautifully decorated shamiana.

As the Governor came to the artistically decorated dais, the National Anthem « Jana-gana-mana » was struck by the Navy band. The huge gathering stood to a man, in pin-drop silence as the strains of the National Anthem went up. After the National Anthem, the Governor and Lady Bajpai took their seats on the dais.

Mr. Hira then welcomed the guests to the function. He recalled the circumstances of the birth of the G. I. P. Railway on 16th April 1853 and outlined its growth and development during the past hundred years. He ended his speech by dedicating himself and his untiring band of railway workers to the cause of the Nation and « to keeping the vital arteries of traffic comprising the Central Railway, active and healthy ».

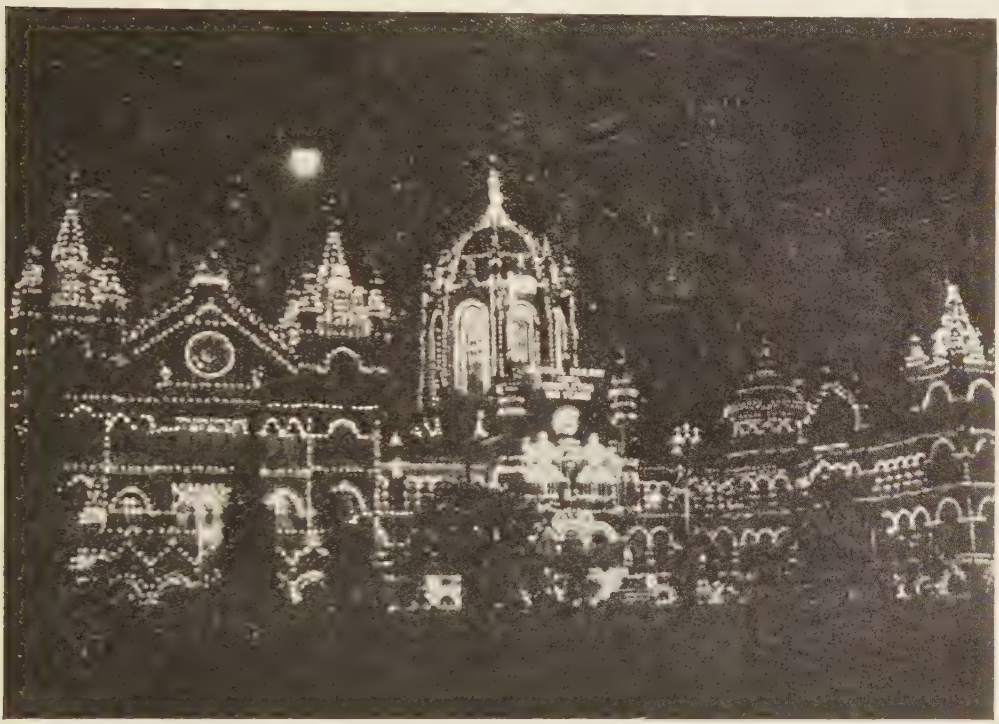
Mr. F.C. Badhwar, Chairman of the Railway Board, who had specially come down

to Bombay from Delhi, to participate in the Centenary Celebrations of the Central Railway, next addressed the gathering. While comparing the occasion to a birthday party, he explained how the railways were striving their utmost to serve the country in handling the increasing demands for transportation. It was customary on such occasions, he pointed out, to give presents to the host and said that he expected the people to give the railways a present in the form of consideration and understanding of their problems.

Thereafter the Governor of Bombay, Mr. BAJPAI addressed the distinguished gathering. He said that he was happy to be associated with this very pleasant function. He congratulated the Railways in general and the Central Railway in particular, upon the services rendered by them in the past and hoped that the Railways in India would keep pace with the developments of mechanical science and continue to be the vital carriers of the country.

After this, the General Manager requested the Governor, on behalf of the Ministry of Railways, to accept the Centenary Souvenir Volume, specially brought out by the Ministry, depicting the progress of Indian Railways during the hundred years from 1853 to 1953.

This was followed by a touching ceremony at which twelve of the loyal railway employees with the longest service were awarded silver medals by His Excellency the Governor. As the General Manager called out the names of these employees and made a brief mention of their service



Illuminations at the Headquaters Office at Victoria Terminus, Bombay.

on the Central Railway, a wave of applause came from the audience. It was a proud day for these employees who had given their best to the railway through their long association with it.

The National Anthem was again struck. The thousands who had assembled to witness these solemn celebrations stood to attention and after the departure of the GOVERNOR and Lady BAJPAI, the ceremony came to a close.

The distinguished guests then moved on to platform No. 9 along which were arrayed a representative selection of « *old* » and « *new* » locomotives and carriages. The latest steel bodied coaches being built by the Hindustan Aircraft Factory as well as the new goods locomotives built at Chittaranjan, the newest air conditioned coach built in the Matunga Workshop as well as the new multiple unit coaches running on the Bombay suburban section were on display. Behind the main dais, on platform No. 9, were also arranged a few interesting exhibits; the « Jewel Studded Tunnel », « Teleprinter », « Automatic Telephone Exchange », « Relief Map of India » and a series of transparencies entitled « Then » and « Now ».

At dusk, the Headquarters offices of the Central Railway were brilliantly illuminated by a myriad lights transforming the whole place into a veritable fairyland. Huge crowds started pouring in, and in front of Victoria Terminus was a surging, seething ocean of humanity admiring the Gothic splendour of the building. The crowds continued till late into the night. The enthusiasm and exuberance of the people of Bombay seemed to know no bounds. It was certainly a historic day for Bombay.

One of the suburban trains running on the Main Line and another running on the Harbour Branch were also brilliantly illuminated and they continued to attract thousands. The engine of the Calcutta Mail leaving Victoria Terminus at 8.30 p.m. on that day and the Madras Mail leaving at 9.00 p.m. were elegantly decorated with a festoon of lights. By a happy coincidence the Governor of Bombay travelled the same night to Poona by the decorated Madras Mail.

On the main entrance to V. T. station on the south side, an illuminated map of India showing the evolution of the Central Railway by stages stood attracting huge crowds.

Illuminations of the Headquarters building and the exhibition of « Then » and « Now » at platform No. 9 were kept on till the midnight of Sunday the 19th April 1953. So great was the popular enthusiasm and so huge were the crowds who came to witness these lights, that hundreds of armed police and Watch & Ward staff had to be commissioned specially to regulate the traffic. No single function in Bombay, perhaps, ever evoked so much enthusiasm and interest as the Centenary Celebrations of the Central Railway.

Young and old, rich and poor, the people of Bombay will continue to talk about the festivity for a long time. Perhaps, just as long, if not longer, as did our fore-fathers about the day when the first train steamed out of Bombay amidst « thunders of artillery and shouts of assembled thousands ».

# Indian Railways—1853-1953.

## Background to the new phase of development initiated by partition and the later regrouping of the systems,

by F. C. Badhwar, Chairman, Indian Railway Board.

(From *The Railway Gazette*, March 20, 1953.)

Indian Railways are completing a hundred years of development, for the first passenger train ran from Bori Bunder (Bombay) to Thana, a distance of 20 miles, on April 16, 1853. This was widely acclaimed at the time as the first event of its kind not only in India but in all Asia. article therefore outlines the beginnings, development, and present progress of railways in India.

The success which attended the early development of railways in Great Britain showed clearly the many advantages to be derived from the new form of transport in

The Railway Staff College at Baroda.

From this small beginning, railway construction has developed steadily, radiating inland from the principal ports and connecting most of the important centres in the country until reaching its present route-mileage of 34 120. The relative importance of railways in India is all the greater because alternative forms of inland transport have not been developed to nearly the same extent as in Western countries. This a country of considerable distances, politically still unconsilidated, and requiring large-scale movement of troops and military stores. In addition, considerable importance was attached to the bulk movements of raw materials to the ports and to the distribution of imported goods in the hinterland.

Within twenty years of the opening of the Stockton & Darlington Railway in

England, proposals were initiated by British interests for the construction of railways in India. Apprehensions regarding the prospects in a new and industrially backward country of an entirely novel form of inland transport were dispelled by the detailed studies and investigations made by a number of private and official experts, notably G. T. Clerk, J. Chapman, Colonel Kennedy, Macdonald Stephenson, and F.W. Simms.

Taking into account the difficulties common to railways in all countries in those early days and the special and peculiar obstacles, such as monsoon floods, severe storms, extremes of climate, damage by insects, and by the luxuriant tropical vegetation, and the difficulty and expense of securing the services of competent engineers and technicians, the Court of Directors of the East India Company preferred a cautious approach, and decided that the first attempts should be made on a limited scale. In accordance with this policy, contracts for the construction of short experimental lines were entered into with the East Indian Railway Company for a line from Howrah to Ranigunj (120 miles), with the Great Indian Peninsula Railway Company for a line from Bombay to Kalyan (33 miles), and with the Madras Railway Company for a line from Madras to Arkonam (39 miles).

### Ambitious construction programme.

The growing success of railways in the West and the official attitude of Government indicated some advantages in planning construction on a larger scale, and Lord Dalhousie, who was then the Governor-General, urged the importance of a speedy and wide introduction of rail communications throughout India, pointing out the great social, political, and commercial advantages of constructing railways between the chief cities. He recommended, in the first instance, a system of trunk lines connecting the hinterland of the Bombay, Bengal, and Madras Presidencies with their respective principal ports and with each other. The trunk lines suggested were: (*a*) from Calcutta to Lahore; (*b*) from Bombay to North India to meet at some point the Calcutta line to Lahore; (*c*) connecting Bombay and Madras; and (*d*) from Madras to the Malabar Coast.

Although the East Indian and the Great Indian Peninsula were the two earliest railway companies to be formed, the desirability of developing railways on the lines proposed by Lord Dalhousie was accepted by the Court of Directors of the East India Company, and by the end of 1859 eight railway companies had been formed with a capital under guarantee of £ 52 1/2 million sterling for the construction of nearly 5 000 miles of lines. These eight companies were: (1) the East Indian, (2) Great Indian Peninsula, (3) Madras, (4) Bombay, Baroda & Central India, (5) Eastern Bengal, (6) Indian Branch, later the Oudh & Rohilkhand, (7) Sind, Punjab & Delhi, later merged in the North Western State Railway, and (8) the Great Southern of India, later the South Indian Railway.

### First Government-Company agreements.

Chief interest in railway developments during this period centres on the Government's policy towards assisting the construction of railways in India. As there were practically no resources in the country in regard to finance and technical personnel, it was taken for granted that railways should be constructed and managed through the agency of British companies. At the same time, British experience emphasised the necessity for providing safeguards against a repetition in India of the evils of unrestricted private enterprise in the railway field elsewhere. Almost from the very commencement, therefore, Government was induced to retain certain general powers of control and regulation within the limits of which the companies were allowed sufficient latitude to construct and manage their undertakings. Thus, for instance,

PAKISTAN
INDIA
E. PAK.
BURMA
ARABIAN SEA
BAY OF BENGAL
CEYLON
PESHAWAR
Durgai
Landi Khana
Khyber
Jamrud
Khyber Pass
Kohat Cant
Thal
Bannu
Lake Marwat
Manzai
Fort Sandeman
Bhakkar
Mari Indus
Dera Ismail Khan
Kundian
Mianwali
Kalabagh
Bhaun
Dhok Khel
Talagang
Chakwal
RAWALPINDI
Mandra
Wah
Hasan Abdal
Hasanabdal
Attock
Peshawar
Nowshera
Mardan
Swabi
Taxila
Gujrat
Lala Musa
Gujranwala
Wazirabad
Sialkot
Narowal
Kamoke
Shahdara
Lahore
Amritsar
Jammu
Kathua
Pathankot
Nagrota
Jogindernagar
Sarogodha
Shahpur
Khushab
Jhang
Lyallpur
Gojra
Toba Tek Singh
Kamalia
Montgomery
Okara
Kasur
Ferozepore
Ludhiana
Sirhind
Ambala
Simla
Kalka
Dhuri
Patiala
Jullundur City
Phillaur
Nakodar
Jagraon
Ludhiana
Moga
Ferozepur
Fazilka
Bhatinda
Sirsa
Hissar
Rohtak
Jind
Sonepat
Panipat
Karnal
Kurukshetra
Ambala
Saharanpur
Muzaffarnagar
Meerut City
Meerut
Hapur
Ghaziabad
Delhi
Shahdara
Tughlakabad
Faridabad
Rewari
Gurgaon
Palwal
Mathura
Aligarh
Hathras
Etah
Kasganj
Farrukhabad
Fatehgarh
Shikohabad
Firozabad
Etawah
Kanpur
Unnao
Lucknow
Rae Bareli
Sultanpur
Partabgarh
Jaunpur
Phaphund
Sayan
Banaras
Mughal Sarai
Allahabad
Manikpur
Satna
Katni
Jubbulpore
Howbagh
Mandla Fort
Nainpur
Balaghat
Gondia
Bhopal
Ujjain
Indore
Harda
Itarsi
Betul
Ellichpur
Khandwa
Akola
Amraoti
Badnera
Jalgaon
Bhusaval
Dhulia
Nasik
Igatpuri
Kalyan
Thana
Bombay
Ahmadnagar
Poona
Dhond
Baramati
Pandharpur
Sholapur
Kurduwadi
Vaghnath
Purna
Janiampet
Ramgundam
Bhiknur
Kazipet
Kochin
Alir
Secunderabad
Hyderabad
Mahbubnagar
Macheria
Gulbarga
Wadi
Bijapur
Miraj
Karad
Kolhapur
Chalisgaon
Manmad
Ahmadnagar
Aurangabad
Jalna
Parbhani
Purna
Akola
Wardha
Nagpur
Ajni
Tumsar Road
Gondia
Raipur
Dhamtari
Rajim
Nagbhir
Balharshan
Sirpur
Adilabad
Chanda
Warora
Chandrapur
Ballarshah
Kantabanji
Titlagarh
Likma
Theruvali
Gunupur
Ganjam
Naupada
Vizianagram
Vizagapatam
Waltair
Bhadrachellam Rd
Dornakal
Samalkot
Cocanada
Somagundam
Narsapur
Bhimavaram
Masulipatam
Bezwada
Guntur
Nallapalle
Ongole
Kavali
Nellore
Gudur
Tada
Pakala
Madras
Arkonam
Chingleput
Jalarpet
Salem
Erode
Coimbatore
Podanur
Shoranur
Calicut
Cannanore
Mangalore
Hassan
Arsikere
Birur
Shimoga
Bangalore
Mysore
Chamarajnagar
Metur Dam
Morapoor
Dolacamund
Chelama
Tadpatri
Cuddapah
Kottur
Rayadrug
Harihar
Chitaldroog
Chikjajur
Hindupur
Sagara
Renigunta
Jolarpet
Vellore
Cuddalore
Porto Novo
Chidambaram
Mayavaram
Negapatam
Tanjore
Trichinopoly
Pt. Calimere
Pamban
Madura
Dindigul
Kankesantural
Cochin
Palghat
Mandamadurai
Virudhunagar
Tuticorin
Manamadura
Manivachi
Quilon
Trivandrum
Tiruchendur
Puttalam
Trincomalee
Batticaloa
Mahio
Matale
Kandy
Badulla
Colombo
Ragama
Opanake
Galle
Matara
Jhansi
Orai
Kalpi
Gwalior
Shivpuri
Sheopur Kalan
Chhabra
Kota
Chittorgarh
Neemuch
Ratlam
Nagda
Ujjain
Dewas
Shujalpur
Agar
Maksi
Biaora
Rajgarh
Khachrod
Nagda
Ujjain
Dewas
Shujalpur
Agar
Maksi
Biaora
Rajgarh
Khachrod
Ratlam
Godhra
Anand
Nadiad
Ahmedabad
Viramgam
Wadhwan
Surendranagar
Dhrangadhra
Halvad
Morvi
Rajkot
Jetalsar
Jamnagar
Okha
Porbandar
Kuranga
Dwarka
Veraval
Junagadh
Keshod
Gondal
Dhoraji
Jetpur
Wankaner
Barwala

under the arrangements originally agreed to, the Government retained the power to require a reduction in rates and fares when the net receipts exceeded 10 per cent return on the capital outlay on the lines. Also, the Government reserved the right to control and give directions to the servants of the company and to appoint a Government Director with powers of veto.

Again, interest was payable to the company at 5 per cent per annum on the capital sum paid into the Treasury. Also, the net profits of the line, after setting aside a contribution to reserves for making good the deterioration of assets, was to be applied in the first instance towards the repayment of interest to Government. It was also laid down that the mails and postal servants were to be carried free of charge. Another condition was that after 99 years, the land and works of the railways were to become the property of the Government, the rolling-stock and other movable property being paid for at a fair value. The Government also retained the option of purchasing the lines within six months after the first 50 years. There were variations in detail in respect of different companies, but there was no decrease in subsequent years in the essential powers of Government in exercising control over these companies.

### First development phase, 1749-1869.

The first phase of railway development in India may be said to extend from 1849 to 1869, during which period the original guaranteed railway companies proceeded with the construction of the main trunk lines. Although great emphasis was laid on the advantages of entrusting railway development to the agency of private companies, the conditions which they succeeded in obtaining from Government left very little risk to the companies themselves. All the original applicants for concessions for the promotion of railways demanded that a minimum return should be guaranteed by the Government on their capital; and as companies could not then be promoted without this condition, a guarantee of 5 per cent was eventually agreed to, coupled with the free grant of all land needed for railway purposes.

In return, the companies were required to share the surplus profits half-yearly with Government, after the guaranteed interest for the half-year had been met — the rate of exchange for the remittance of interest charges being reckoned at 22 d. to the rupee — and to sell the railways to the Government, after 25 years, on the basis of specified rates; they were, moreover, to permit the Government to exercise control over all expenditure and over the management and working of the lines. The guaranteed rate of interest was high and experience later showed that these conditions assisted little towards either the rapid development of the lines or in economy in the cost of their construction. These conditions might have proved beneficial to the country if the guaranteed interest had been earned, but expectations in regard to profits remained unfulfilled because of the high costs of the construction of the new lines.

### High construction costs.

The increases in these costs were attributed to a number of factors. One was that the standard of construction was far higher than required for the general conditions prevailing in the country, or for the actual functions which the railways were designed to perform. Many conveniences were provided which, though desirable in themselves, were not essential for the efficient operation of the railways. Some experimental lines were built with double track, the necessity for which did not arise till some generations later. Increases in the costs of construction were also caused by alterations in the alignments after work had actually begun. The political and military upheaval of 1857 also aggravated the position by causing suspension of all work for a time.

Consequently, earnings which might have

been sufficient to pay interest charges on well-controlled and reasonable expenditure proved inadequate to meet the guarantee on the heavy outlays actually incurred, and Government had to make good the deficits. The method of sharing the profits itself also operated against the interests of the State. Even in cases where the earnings for the whole year were sufficient to cover interest charges, the operation of the clause requiring surplus profits to be devided half-yearly deprived Government of the benefits of the first half of each year, when traffic was usually much more brisk than in the latter half of the year, and sometimes resulted in a deficit on the full year's transactions.

By the end of 1859, the eight companies referred to earlier had an authorised capital of £ 34.13 million, of which £ 27.08 million were actually raised. The amount of guarantee paid by Government to the companies by January 1, 1860, amounted to £ 3.84 million. The earnings of the railways during this period amounted to only a little over half a million pounds. It is not possible, however, from these figures to estimate the commercial value of the lines, as out of £ 27.08 million raised for expenditure, only £ 4.09 million, representing the amount which had been expended on the 702 miles opened for traffic, could yield any return.

During the early 1860s there arose further difficulties. One was the inability of the companies themselves to raise further capital, as a result of which they had to apply for Government aid in the shape of advances. The companies to whom such advances were made were charged interest at 5 per cent, and the Government shared in the undertaking in proportion to the amount of such advances.

### Rise in value of Rupee.

A further complication arose in consequence of the appreciation in value of the rupee. When the agreements were made, the rate of exchange for the rupee was 1 s. 10 d. and it was stipulated in all the contracts that the rupee should, in the accounts between the Government and companies, be converted into sterling at that rate. When the value of the rupee rose to 2 s. the Government spent in India the equivalent of 2 s. for every 1 s. 10 d. paid into the Government's account in England for this expenditure in India. The loss on this account during 1862-63 alone was about £ 2.4 million. Out of the £ 13.16 million paid by Government to the companies during the 14 years 1853-67 towards guaranteed interest, only £ 3.3 million was paid back out of the earnings of the railways. The annual charge upon the Government under this head had increased in 1865 to well above £ 2.70 million, taking into account both the guaranteed interest and losses by exchange operations.

This financial drain on Government made a change in the railway development policy imperative. Reviewing the first 20 years of railway development in India, Lord Lawrence, the Governor-General in 1869, wrote : « On examining the conditions under which the State is now called upon to make good a part of the guaranteed interest on Indian railway capital, it at once becomes clear that the liability of the Government to a permanent and probably increasing charge on the revenues has largely increased by the arrangement under which the Government could derive no profit whatever... The whole profit goes to the companies and the whole loss to Government. It, therefore, follows almost as a positive certainty that there will be a permanent charge thrown on the Government for guaranteed interest so long as the present system continues. »

He concluded by recording a very decided opinion to the effect that the direct agency of Government would be more economical than that of the railway companies and that there would almost certainly be advantages to the State financially and, therefore, to the community of India at large, if the Government were to construct railways with money directly borrowed from the market for the purpose.

### Construction by Government.

As private enterprise could not be attracted to railway projects without a guaranteed return and as its ability to raise adequate capital for such purposes also was doubtful, the State, with its superior credit in the money market, appeared the obvious agency for undertaking further developments. Further, the provision of new railway lines had failed to keep pace with the increasing requirements of the country and the new mileages opened each year had hardly averaged 350. The need for a reorientation of the railway policy was, therefore, accepted, and approval was accorded to the discontinuance of the guarantee system and to the use of State agencies instead for new constructions. The Government accordingly undertook a number of new constructions, such as the Indus Valley and the Rajputana Railways.

The original contracts with the companies were modified in order to ensure more effective control but, curiously enough, it was at the same time agreed with the companies that the Government should keep no account of outstandings in respect of guaranteed interests paid to the companies, and would cancel past debts, which there was little hope of the companies paying off in any case. It was also decided by the Secretary of State, in spite of strong protests from the Indian Government, to waive the right to purchase the Great Indian Peninsula, the Madras, and the Bombay, Baroda & Central India Railways, on the expiry of the first twenty-five years of their leases.

Double-deck third class coach of the East Indian Railway, built at Howrah workshops in 1864.

### Introduction of metre gauge.

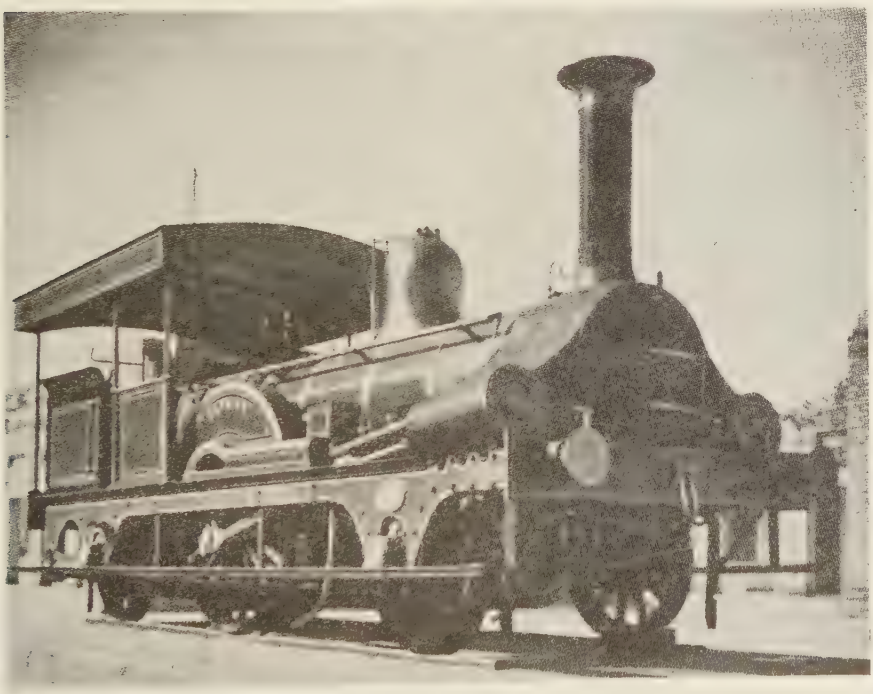
The system of trunk lines proposed by Lord Dalhousie was completed by 1871, and 5 051 miles of railways, out of an approved total of 7 482 miles, had already been opened. An important decision affecting a change in uniformity of gauge was now taken at the instance of Lord Lawrence, who considered that it was more important to extend the benefits of rail communication, even if this involved a break of gauge, than to standardise the

broad gauge (5 ft. 6 in.) throughout India. The cost of construction of broad gauge lines averaged about £ 17 000 a mile at the time and, with the resources available to Government, the provision of new lines of this gauge could not be as rapid as of metre-gauge lines, which cost about £10 000 per mile only and would enable larger territory to be covered. It was, therefore, decided that Government should build railways on the metre gauge. Also by 1875 the allotment for railways was increased, but the Afghan war and recurring famines reduced the funds actually available for rail construction.

THIS LOCOMOTIVE,
THE FIRST WHICH RAN
PASSENGER TRAINS ON THE EAST INDIAN RAILWAY
BETWEEN
HOWRAH AND RANEEGUNGE
AND CONVEYED TROOP TRAINS TO RANEEGUNGE
IN THE
MEMORABLE YEAR 1857:
WAS PLACED ON THIS PEDESTAL
JANUARY 22ND 1901.
AS A FITTING MEMORIAL IN THESE BOUNDS
OF THE TERMINATION OF THE GLORIOUS REIGN OF
OUR BELOVED EMPRESS AND QUEEN
VICTORIA THE GOOD.

### New guarantee system.

The policy of State construction, however, held until 1881, after which the limited ways and means position of Government made it necessary to turn again to companies for the construction of railways under some form of guarantees. The new



2-2-2 locomotive « Express », the first to run in passenger service on the East Indian Railway, as commemorated in the plate shown above.

guarantee system, however, differed from the old one and the lines promoted under the new system were termed « State Railway lines worked by companies ». The main differences between the new and the old guarantee terms were that the rate of guaranteed interest was lower and that the terms generally were easier for the Government. The new railway lines then promoted were the Indian Midland (1882-5), later merged in the G.I.P., the Bengal Nagpur (1883-7), the Southern Mahratta (1882), and the Assam Bengal (1891) Railways.

The famines of the 1870s in the province of Bihar and the Deccan peninsula stressed the need for more rapid extensions of railways and a portion of the special Famine Insurance Grant was diverted for expenditure on new lines of a productive nature. In 1883, under the advice of a Parliamentary Committee, the limit of borrowing was increased from Rs. 2 crores to Rs. 3 1/2 crores annually, of which Rs. 3 crores were assigned wholly to railways. In 1885 some funds had to be diverted for the construction of the costly strategic and unremunerative lines on the North West Frontier, but in 1890 the whole available balance of the Famine Insurance Grant was devoted to railway building.

Despite the raising of the limit of capital expenditure, and of the rebate terms in 1893, progress was not considered satisfactory, and the terms for the compagnies were again revised in 1896, the companies now being offered either an absolute guarantee of 3 per cent., with a share of surplus profits, or a rebate up to the full extent of the main lines' net earnings to supplement their own net earnings, the total being limited to 3 1/2 per cent on the capital outlay.

The progress of railway development during the last century is summarised briefly in Table 1, which indicates the position in terms of the route-mileage, capital outlay, gross earnings, working expenses, and net earnings.

The net losses to Government as a result of payment of guaranteed interest to the railway companies, after deducting the amounts recovered from the net receipts totalled about £ 51 1/2 million.

### Formation of the Railway Board.

At the turn of the century, the time was considered ripe to examine the adequacy of the existing administrative machinery for dealing with railways. In october, 1901, a Special Commissioner for Indian Railways, Sir Thomas Robertson, was appointed to inquire into and report on the general administration and working of Indian railways. As a result of his studies and recommendations, the central organisation for Government control of Indian railways began to assume its present form.

TABLE 1

**Mileage And Results, All Railways, 1853-1900**

| Year | Route-mileage | Capital outlay | Gross earnings | Working expenses | Net earnings |
|---|---|---|---|---|---|
| | | Rs. 000 | Rs. 000 | Rs. 000 | Rs. 000 |
| 1853 | 20 | 37,96 | 90 | 41 | 49 |
| 1860 | 838 | 26,66,00 | 66,67 | 37,08 | 29,59 |
| 1870 | 4 771 | 90,00,50 | 6,66,67 | 3,63,15 | 3,03,52 |
| 1880 | 8 996 | 1,28,56,91 | 12,86,55 | 6,48,00 | 6,38,55 |
| 1890 | 16 404 | 2,13,67,04 | 20,67,01 | 10,30,89 | 10,36,12 |
| 1900 | 24 752 | 3,29,53,34 | 31,54,32 | 15,09,31 | 16,45,01 |

The commencement of construction of railways by the State created the need for a separate State Railway Directorate as distinct from the Public Works Department. This Directorate was formed in 1874 and placed in succession first under one Central Director, later under three Territorial Directors with a Central Director of Railway Stores to provision them, and, after further experience, again under a central Director-General of Railways. In 1897, as the scope and responsibilities of this post increased, it was replaced by that of a full Secretary to the Government of India. Robertson had also recommended the setting up of a small board headed by a President or Chief Commissioner, with two other Commissioners of high railway standing. The Railway Board was eventually set up in 1905, and to it were transferred control of all matters pertaining to railways in India.

### Developments, 1900-1914.

The demand for railway expansion continued but the expenditure on new construction fell far short of popular expectations. The Government appointed the Mackay Committee in 1907 to examine the country's requirements of new railways and explore means for financing such new constructions. During this period, the annual losses on railway account had disappeared and the gain to the State from its railway investment had become a regular feature. That railways in India were a paying proposition was remarked upon by the Mackay Committee, which, commenting on the inadequacy of rail transport facilities and the urgency of large-scale constructions, expressed the views that even a total route-mileage of 100 000 « was short of that which will ultimately be found to be necessary in India », and « the steady and even rapid development of the railway system of India should be regarded by Government as one of its important duties ».

It was recommended that £ 100 million should be spent on new construction and development in the next eight years. New railway constructions, however, continued to progress at a much more modest rate, and during the period 1900-14 only about 10 000 route-miles were added. This was substantially less than the increase in route-mileage during the preceding 15 years. The progress of new constructions was, however, fairly steady till the first world war slowed it down.

Indian railways contributed appreciably to the first world war by diverting much of their resources to meet military requirements. The transport of troops, materials, and supplies at short notice had to be arranged, and heavy demands for materials and personnel for railways in East Africa and Mesopotamia had to be met. Many sections of railway workshops were also diverted to the production of war equipment. As overseas supplies of railway materials and components from the United Kingdom, the principal supplier, were cut off, arrears of maintenance and renewals accumulated and railway assets in service were reduced to a serious state.

### After the First World War.

At the end of the war, the transport situation in India had become grave, and all interests concerned with agriculture, trade and industry were unanimous in demanding drastic and urgent steps to rehabilitate the Indian railway system to meet the economic requirements of the country.

At about the same time, certain important matters of future railway policy required early consideration. The contract with the East Indian Railway Company was due to expire in 1919. Public opinion had consistently declared its preference for State management, and was not satisfied with railways in India being managed by British companies with boards of directors in London. Moreover, it saw no reason why these companies should continue to obtain recruits from overseas for almost all their higher posts, believing that good material was available in the country.

Then there was the question of the industrialisation of the country and the positive contribution that railways could make towards accelerating its pace. It was held that Government management would result in more positive and earlier measures favourable towards indigenous industrial development than a continuation of company management with a natural bias towards vested interests and good dividends for shareholders. Also, procurement of railway stores afforded a valuable opportunity for encouraging domestic industry by giving it a degree of preference. It was felt that company-managed railways, with boards of directors in England, could not be expected to respond to such developmental policies, whereas State management would be more sympathetic towards economic advancement in the country.

Finally, Government would recognise more readily than the companies the need for improving conditions and amenities for third class passengers. The force of public opinion in favour of State management had gained strength and, coupled with impending constitutional changes, led to a decision to postpone any far-reaching changes until a comprehensive inquiry into all aspects of the question had been completed. Table 2 shows the results of the working of Indian Railways from 1901 to 1923-24.

### Towards State Management.

A committee was set up in 1920 with Sir William Acworth as Chairman, to undertake a comprehensive inquiry into questions relating to the management, finance and the future control and organisation of railways. The committee, by a majority, recommended termination of the contracts with the companies as they fell due. The financial policy of the Government of India, which made no provision for either reserves or for ensuring a steady flow of funds for financing railway construction and improvements, came in for severe criticism, and the committee recommended the separation of the Railway Budget from the General Budget of the country. The need for making adequate provision for depreciation and limiting the demands of the State on railway surpluses was also emphasised. On a number of other matters of topical interest, such as Indianisation of the higher cadres, stores purchases, and rating policy, the recommendations of the committee were generally in conformity with the public demand.

The Ackworth Committee's recommendations were accepted by the Government, and by a resolution passed on September 20, 1924, railway finance was separated from the general finance of the country. The Railway Board was reorganised, with a Chief Commissioner and a Financial Commissioner, besides technical Members. The technical Directorates were also reinforced and expanded. As regards the policy of State management, the Government was already operating three railway systems, namely, the North Western, the Oudh & Rohilkhand, and the Eastern Bengal Railways, and on January 1, 1925, the East Indian Railway was taken over by the State and merged with the Oudh & Rohilkhand

TABLE 2

| Year | Route-mileage | Capital outlay | Gross earnings | Working expenses | Net earnings |
|---|---|---|---|---|---|
| | | Rs. 000 | Rs. 000 | Rs. 000 | Rs. 000 |
| 1901 | 25 332 | 3,39,16,89 | 33,60,38 | 15,72,45 | 17,87,93 |
| 1910 | 32 099 | 4,39,04,73 | 51,14,22 | 27,15,72 | 23,98,50 |
| 1919-20 | 36 735 | 5,66,37,77 | 89,15,32 | 50,65,65 | 38,49,67 |
| 1923-24 | 38 039 | 7,17,93,02 | 1,07,79,66 | 68,44,77 | 39,34,89 |

Railway. On May 1, 1925, the contract with the Great Indian Peninsula Railway Company expired and this line was also taken under State management. In 1929, the Burma Railways were taken over by the State and thus five major systems were operated under direct State management by 1929-30.

### Indian Railways, 1924-37.

The first six years after the adoption of the Convention instituting a separate budget for railways witnessed the introduction of a series of other far-reaching changes in finance and organisation. A proper depreciation fund was set up. The accounting machinery was examined by Sir Arthur Lowes Dickinson and a beginning made towards the separation of the accounts from the audit. The administrative set-ups of individual railways were also overhauled and with a view to decentralisation in the case of the larger systems, particularly the North Western and the East Indian, the divisional system of organisation was introduced. A more progressive policy designed to improve the conditions of railway labour was also adopted. Systematic programmes of open line improvements and new construction were drawn up and a substantial addition was made to the route-mileage. The capacity of some intensively-worked lines was increased by doubling and quadrupling.

The programme of rehabilitation and modernisation included improvement of the permanent way, strengthening of bridges, remodelling of yards, new station buildings, and more staff quarters. Several workshops were extended and better equipped. The electrification of suburban services in the Bombay and Madras areas was undertaken during this period. The total capital outlay incurred on all these items during the period 1924-32 was the equivalent of about £ 90 million. The construction of new lines alone amounted to an addition of 5 360 route-miles at a capital expenditure of about £ 30 million, figures which would have been greatly exceeded but for the world slump of the early 1930s.

### Expansion and prosperity.

Railway revenues were also high and after meeting operating expenses and appropriation to depreciation fund, a handsome surplus was left to meet the contribution to the general revenues of Government and to build up a reserve fund. The financial results of Indian State-owned railways during 1924-30 are summarised in Table 3.

TABLE 3

**Financial results of Indian State-owned Railways, 1924-30**

| — | 1924-30 (average) (in lakhs of Rs.) |
|---|---|
| Gross traffic receipts | 1,01,22 |
| Operating expenses | 53,40 |
| Depreciation fund | 11,31 |
| Net traffic receipts | 36,51 |
| Net miscellaneous receipts | 80 |
| Net revenue | 35,71 |
| Interest charges | 26,94 |
| Surplus | 8,77 |
| Contribution to general revenues | 5,98 |
| Railway Reserve Fund | 2,79 |

### World slump.

The years of prosperity came to an unexpected and abrupt end with the world-wide slump in 1929-31 when construction programmes were suddenly and severely curtailed. Railway receipts, following the general depression in agriculture, industry, and trade, dropped steeply and retrenchment of staff had to be enforced to keep down further losses. The accumulations in the reserve fund were almost wiped out within a year or two, and the depreciation fund had to be raided to the extent of about £ 23 million in order to meet the

interest charges on capital, after the suspension of contributions to general revenues.

It was only in 1937-38 that the situation improved slightly. The financial position of Indian railways during the depression is shown in Table 4.

On April 1, 1937, Burma was separated from India and the Burma railways also parted company from the Indian railway system.

TABLE 4

**Financial results of Indian State-owned Railways, 1930-37**

| | 1930-37 (average) (in lakhs of Rs.) |
|---|---|
| Gross traffic receipts | 89.88 |
| Operating expenses | 80.52 |
| Depreciation fund | 13.43 |
| Net traffic receipts | 25.93 |
| Net miscellaneous receipts | .48 |
| Net revenue | 26.41 |
| Interest charges | 32.18 |
| Surplus | 8.77 |
| Contribution to general revenues | 82 |
| Railway Reserve Fund | 2.27 |

## Second World War.

It required the traffic demands of the second world war to bring prosperity back to Indian railways. Increased earnings began from 1939-40, resulting in surpluses which more than made up for the loans previously taken from the depreciation fund to meet deficits in the thirties and pay off the contributions then suspended. The war was more protracted than its predecessor and inflicted far greater wear and tear on railways.

Attrition of assets due to intensive use and postponement of renewals, and even of essential maintenance, in many cases due to lack of resources, left Indian railways by 1945 in an even more serious state than they had been in 1918. When they emerged from the depression in 1937, the railways faced the problem of overtaking the arrears of maintenance and replacements since 1931. But the outbreak of the Second World War in 1939 interrupted this process, as overseas sources of supply diverted their production to meet the exigencies of the war and mobilised all their resources for war efforts.

During the first phase of the war, Indian railways were called upon, despite their accumulated deficiencies and difficulties, to release locomotives, wagons, and track material for the Middle East, the defence responsibility of which had been allotted to the Indian Command. Over 8 per cent of metre-gauge locomotives and 15 per cent of metre-gauge wagons of Indian railways as well as 4 000 miles of track and 4 million sleepers were released for use for military purposes. This necessitated the dismantling of 26 branch lines as well as curtailment of services on many others.

Later, India became the base for mounting a major offensive against Japan and the load on railways increased still further. A large number of railway workshops were diverted to the manufacture of munitions while the maintenance and renewal of railway equipment received little attention. The continuous strain imposed on Indian railways by demands for heavy military movements brought them almost to breaking point. Enormous arrears of renewals and replacements accumulated and indigenous facilities for rehabilitation were appreciably reduced, or incapacitated, by the mobilisation of workshop equipment for the war effort.

When hostilities ceased, the railways were faced with major problems not susceptible of immediate solution. Plans for postwar rehabilitation and development were necessarily long-term, but most of these were stultified by the effects of the partition of the country which necessitated the dismemberment of the North Western and the Bengal Assam Railways. In addition to the problems of reconstituting the Indian

parts of these systems into self-sufficient units, and complicated staff changes, there were the formidable difficulties caused by the mass movements of persons who had been displaced from each Dominion.

### Postwar developments.

One redeeming feature of the war on Indian railways was that both the depreciation and the reserve funds were well stocked to meet future expenditure, as little could be purchased during the war. Another important factor was that during the war period the remaining company-managed railways, about the taking over of which by the State there had been considerable controversy during the thirties, had been brought under State management. The acquisition of these British companies' lines afforded an opportunity to use some of the rapidly accumulating sterling balances to good purpose, and the Assam Bengal, Oudh & Tirhur, Bombay, Baroda & Central India, Madras & Southern Mahratta, Bengal Nagpur, and South Indian Railways were all acquired and transferred to State management during the war years.

In dealing with the problems of large-scale rehabilitation it has been necessary to keep in view the enormous increases in the volume of traffic, shown in Table 5.

TABLE 5

**Volume of traffic handled**

| | 1938-39 (millions) | 1949-50 (millions) |
|---|---|---|
| Passengers carried . . | 372 | 1 051 |
| Freight tons carried . . | 86 | 105 |
| Passenger-miles . . . . | 12 589 | 32 844 |
| Freight ton-miles . . . | 17 047 | 23 144 |

The volume of passenger traffic had increased more than two and a half times, and goods traffic had also gone up substantially. On the other hand a large number of locomotives, coaching vehicles and wagons was over-age and obsolete, and the track had deteriorated to dangerous levels demanding severe speed restrictions. All these defects had their inevitable repercussions on the general efficiency of the transport system, by restricting capacity, slowing down the movement of trains, and making the imposition of priorities essential.

Partition had also affected the pattern of traffic, and the loss of the Port of Karachi added to the burden on the Bombay-Delhi route, necessitating augmentation of line capacity, increase of yard capacity and facilities, and reajustment of many other essential operating arrangements. The shock of Partition had, however, mostly been absorbed by the middle of 1948, but the other factors continued to strain the transport system of the country to the utmost and created several grave bottlenecks.

The power position called for urgent attention and was tackled first. As a result of special steps, large orders were placed with early delivery dates for locomotives, and the timely arrival of these brought about a noticeable improvement. Simultaneously it was decided to set up in the country a modern locomotive manufacturing industry for Indian Railways and the new factory at Chittaranjan was completed within two years and has already produced its first 50 engines. It is designed for an output of 120 engines per annum, plus spare boilers and other components. The Tata Engineering & Locomotive Company, a private company in which Government has shares, is also producing boilers and locomotives.

The shortage of coaching vehicles has been the principal obstacle in affording relief to overcrowding in passenger trains. Some progress in providing additional carriages has already been made by railway workshops, and the resources of the Hindustan Aircraft Factory at Bangalore have also been partially utilised for the purpose of producing more coaching vehicles. Substantial improvement is expected when the

new coach-building factory now under construction at Perambur, near Madras, is completed.

### Reorganisation since 1947.

During the five years since Independence, several far-reaching changes in railway organisation and policy have been carried out. A new system of rates and fares, planned on comprehensive lines, was brought into force in 1948. Passenger fares, which used to vary in the past from railway to railway, were standardised throughout the country. The revision of the freight rates system was more difficult, but the necessity for rating reforms had been recognised for some time. A post-war Rating Committee had been set up to undertake a detailed examination of existing rates and make recommendations regarding the changes to be introduced. The revised system, which incorporated many of these recommendations, came into force with effect from October 1, 1948.

The four main features of the new system are: first, the highly individualistic character of some rates was radically modified and a telescopic bias was imparted to class rates, a reform long pressed for by the commercial community; secondly, the difference between the rates on railway risk and owner's risk conditions was rather wide under the previous classification and was now narrowed down to about the difference between two successive classes; thirdly, the large number of special rates was considerably reduced; and, fourthly, the terminal charges were standardised throughout the country.

The overhaul of the machinery for the

A « WP » 4-6-2 locomotive on an express leaving Howrah Terminus, Calcutta

adjudication of rates disputes was also effected at the same time. The former Rates Advisory Committee had not been empowered to enforce its decisions on railway administrations. Its intervention in rates matters was not, therefore, invoked as frequently as it might have been by the trading community due to this limitation. In 1948 the Indian Railways Act was suitably amended and provision was made for the setting up of a Railway Rates Tribunal with mandatory powers.

It was logical that the political independence of the country should create an urge for self-sufficiency on the part of Indian Railways in the technical field. After a careful assessment of the talent available, it was decided in 1949 to form Design and Consultant Wings from the Engineering cadres of railways in India to replace the well-known firms of British Consulting Engineers, who had provided technical guidance for the past three-quarters of a century. Indian Railways were fortunate in possessing civil and mechanical engineers of high calibre with aptitude and some experience in this line of work, with the result that well-organised locomotive, carriage and wagon, and structural and permanent-way design and consultant wings, manned entirely by Indians, are now functioning with complete satisfaction.

### Revision of the Convention.

Another important change was the revision in 1949 of the Convention separating the Railway Finance from General Finance. The original Convention of 1924 was intended to be reviewed after three years, but this review had been postponed for various reasons. The only change brought about during the 25 years since its adoption was the amendment, in 1943, of one of the clauses relating to the determination of the contribution under which Government was empowered to fix the contribution from year to year from 1944-5 onwards. There were some other features of the old Convention which had become out of step with post-war conditions and the present-day requirements of the country. A committee of Parliament was accordingly set up to go into the entire question and its recommendations were generally accepted.

According to the Revised Convention of 1949, the general taxpayer was accorded the status of the sole shareholder in the railway undertaking with a guaranteed dividend of 4 per cent on the loan capital invested as computed annually. The contribution to the depreciation reserve fund was raised to a minimum of Rs. 15 crores a year to enable increased appropriations being made to allow for the high costs of replacement at post-war levels of prices. The financial limit for charging to revenue the cost of minor additions and improvements was raised from Rs. 10 000 to Rs. 25 000 for each individual item.

A special provision was also made to cover expenditure on unremunerative projects for improving operational efficiency in excess of Rs. 3 lakhs, such costs being charged to a railway development fund intended to finance passenger amenities, staff welfare works, and projects which were necessary but financially unremunerative at the time of construction. Finally, the scope of the reserve fund was limited to securing payment of prescribed dividends and to bridging the budgetary gap, should any occur during the currency of the Convention. The Convention was to operate for a period of five years. The Revised Convention is obviously an advance on the original Convention and provides deterrents to any tendency towards overcapitalisation.

### Regrouping of railways.

The regrouping of Indian Railways on a rational and geographical basis, which has been the subject of consideration for nearly a quarter of a century, had by 1949 reached a stage where it could no longer be postponed. The cutting up of the North Western Railway and the Bengal Assam Railway as a result of the Partition of the country had left certain sections within

India which were, relatively, too small and poorly equipped with workshops and other resources for economical working.

Also the federal financial integration of the Indian States had just been completed and by April 1, 1950, the railways belonging to these States, varying from the four route-miles of the Sangli State to the 1 400 miles of Hyderabad State, had become parts of the Indian Government Railway system. The reorganisation of all these lines to form a smaller number of larger and more resourceful systems was imperative in the interests of standards of working, uniformity in operational arrangements and procedures, extension of facilities and reasonable amenities for the travelling and trading public.

As a result of detailed and expert consideration of the question, the Railway Board finalised a scheme for dividing the now-integrated Indian Railways system into six administrative and operating zones. Public opinion was sounded on these proposals and some details were revised as the result of such references. Finally the revised scheme was placed before the Central Advisory Council for Railways, a parliamentary body, which accorded its approval. The first regrouped railway to be formed was the Southern Railway on April 14, 1951. This was made up of the former Madras & Southern Mahratta, the South Indian, and the Mysoré State Railways, with its headquarters at Madras. On November 5, 1951, the Central and the Western Railways were formed, with separate headquarters but both located at Bombay. The former absorbed the Hyderabad State, Dholpur, and Scindia State Railways into the Great Indian Peninsula Railway, and the latter the Saurashtra, Jaipur, Rajasthan, and Cutch State Railways into the Bombay, Baroda & Central India Railway.

The final phase of the programme of regrouping was completed on April 14, 1952, when the Northern, North-Eastern, and Eastern Railways were formed. The Northern Railway represented the fusion of the Eastern Punjab, the Bikaner and the Jodhpur Railways with the Allahabad, Lucknow, and Moradabad Divisions of the East Indian Railway, with headquarters at Delhi. The North Eastern Railway was a case of simple amalgamation of the Oudh Tirhut and the Assam Railways, with headquarters at Gorakhpur. The remaining divisions of the East Indian Railway were combined with the Bengal Nagpur Railway to form the Eastern Railway with headquarters at Calcutta. The extent of the regrouped railways may be seen from the following Table.

TABLE 6

**Route mileage, re-grouped railways**

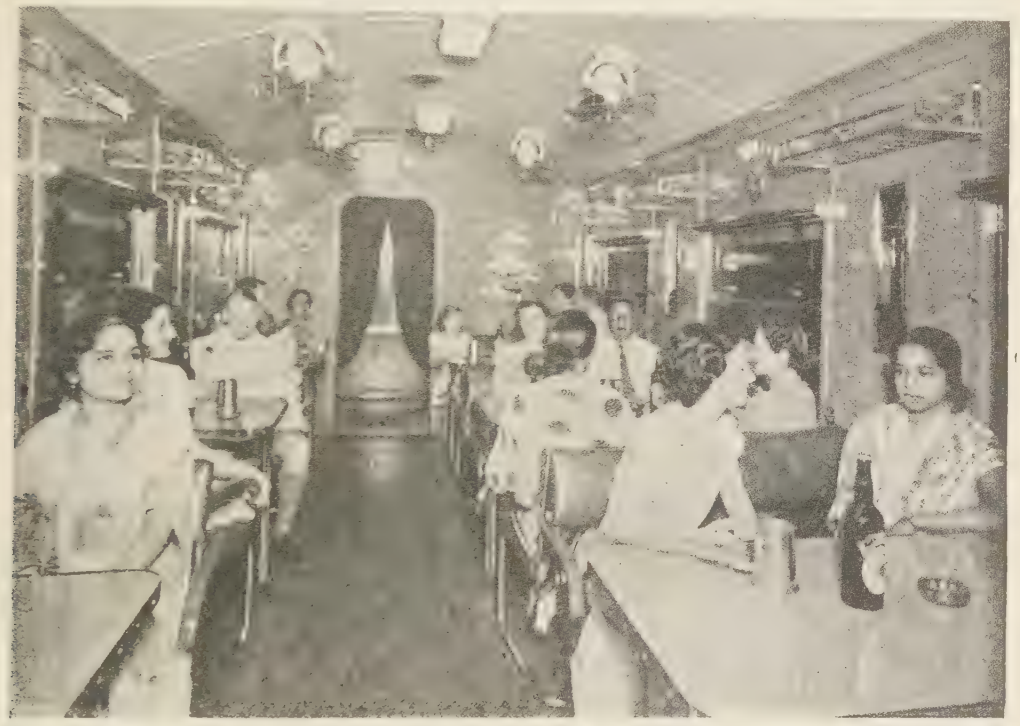
| Railway | Route mileage |
|---|---|
| Southern | 6 017 |
| Central | 5 428 |
| Western | 5 631 |
| Northern | 6 007 |
| North Eastern | 4 787 |
| Eastern | 5 667 |

The executive and administrative organisation of the constituent units of the regrouped railways has been left largely undisturbed. In the case of the railways based on the district pattern or organisation — the Southern, Western, and North Eastern — three regional headquarters have been set up in each zone under the control of Regional Deputy Heads of Departments for intermediate co-ordination and supervision. On the other railways the constituent units have been moulded to the predominating Divisional pattern. Only on the Eastern Railway is there a mixture, the old East Indian divisions being retained as such along with the District organisation of the Bengal Nagpur Railway controlled through a region at Bilaspur. This policy has had the advantage of avoiding any dislocation in the actual working.

**Rehabilitation and expansion.**

Indian Railways have had to plan their programmes of rehabilitation, improvements and new construction within limitations of finance and indigenous resources. New constructions have been few in comparison with the many demands in the country and during recent years the Assam rail link and the connection from Deesa to the new port of Kandla, each about 180 miles in length but traversing widely differing country, have been the only new lines that could be undertaken. Rehabilitation of major assets and the improvements necessary to obtain optimum performance from existing resources have been given the highest priorities in capital programmes. Most of the lines dismantled during the war are being restored, however, and many new constructions are being considered to provide the additional carrying capacity that the Five-Year National Development Plan demands.

Major projects selected for construction during the next three years include a railroad bridge across the Ganga (Ganges) in Bihar, expected to consist of nine spans of 600 ft. each; new lines and doublings for expansions in the steel, coal and cement industries; a 200-mile connection between the Northern and Southern metre-gauge systems; electrification of certain steam-traction sections; many works to increase line capacity of intensively worked lengths; and new railway factories for producing in India a number of railway components that



Interior of modern, broad gauge dining car.

are still imported. The rate of progress on these projects must necessarily depend upon the resources made available from year to year.

It can legitimately be claimed that Indian Railways present on the whole a progressive and commendable record. Their close association with the State has not impaired the observance of commercial principles of working which are so necessary to maintain efficiency, while the public utility aspect of their functions has been steadily kept to the fore. The efforts made in recent years to improve the standards of amenities and comfort for third class passengers deserve special mention. Financially, also, the position of Indian Railways has remained essentially sound, and the large balances accumulated in their reserve funds have been of substantial help to the country. On March 31, 1953, the balances at the credit of the depreciation reserve fund, revenue reserve fund, and development fund had been estimated at £ 90 million, £ 30 million and £ 20 million respectively, totalling £ 140 million. The financial results for 1951-52 are summarised in Table 7.

With so heartening a record during the past hundred years, Indian Railways will enter their second century of public service with every confidence and hope. The fortitude and success with which they have faced the many formidable difficulties of two wars and the partition of the country, when they were far less self-sufficient than at present, augurs well for their ability to deal with future emergencies and to provide India with a transport basis on which her future prosperity can be built.

TABLE 7

**Financial results of Indian Government Railways**

| — | 1951-52 (lakhs of Rs.) |
|---|---|
| Gross traffic receipts | 2,90,82 |
| Ordinary working expenses | 1,94,04 |
| Appropriation to depreciation fund | 30,00 |
| Payment to worked lines | 31 |
| Net traffic receipts | 66,47 |
| Net miscellaneous receipts | —4,72 |
| Net revenue | 61,75 |
| Dividend to general revenues | 33,41 |
| Development fund | 10,00 |
| Revenue reserve fund | 18,34 |

[ 625 .143 (0 ]

# A locomotive rail-stress index,(*)

by C. W. Clarke, A.M.C.T., M.I.C.E., M.I.Mech.E., M.I.E.Aust., M.I.Loco.E.

This investigation was read by the author at a meeting of the *Institution of Locomotive Engineers* (Western Australian Branch). In view, of the interest of this question, we give below an extensive résumé.

### General theory.

The method used consists in determining the deformation of the rail and the stresses set up in the rail by means of the theory of elasticity.

This considers the rail as a continuous member resting on an elastic bed. The reaction at a given point is proportional to the depression at this point and can be written

$$p = - Uy \text{ pounds} \qquad \text{(B-1)} \ (1)$$

in which U is the modulus of elasticity of the ballast.

We know from the theory of bending that the fourth derivation of the elastic curve is proportional to the force by unit of length. The differential equation of the axis of the rail which is deflecting is the following :

$$EI \frac{d^4y}{dx^4} + Uy = 0 \qquad \text{(B-4)}$$

When considering the case of the single wheel of weight P, the solution is given by (2)

$$y = - \frac{P}{8 \beta^3 EI} \cdot e^{-\beta x} (\cos \beta x + \sin \beta x) \quad \text{(B-7)}$$

the coefficient $\beta$ having the value

$$\beta = \sqrt[4]{\frac{U}{4 EI}}. \qquad \text{(B-8)}$$

The bending moment, which is proportional to the second derivation, can be expressed by

$$M = \frac{P}{4 \beta} e^{-\beta x} (\sin \beta x - \cos \beta x) \qquad \text{(B-16)}$$

The intensity of the pressure on the lower face of the rail is

$$p = - Uy$$

$$= P \frac{\beta}{2} e^{-\beta x} (\cos \beta x + \sin \beta x) \qquad \text{(B-14)}$$

The curves of the expressions

$$y = e^{-x} (\cos x + \sin x) \qquad \text{(B-17)}$$

and

$$y = - e^{-x} (\sin x - \cos x) \qquad \text{(B-18)}$$

are the « master » curves, which indicate the corresponding values of the depression of the track and of the bending moment in the rail. They are applicable to every combination of modulus of the track and of moment of inertia of the section of rail. The ordinates are proportional to the pressure under the rail and to the bending moment respectively, and the abscissae to $\beta x$.

(*) Résumé of the original paper, published with the authorization of the « *Institution of Locomotive Engineers* », London.

(1) The equations reproduced have been given the same numbers as in the original paper.

(2) This solution is not strictly exact. A fuller solution for the piece of infinite length with a single concentrated load has been given by M. A. Biot, A.S.M.E., *Journal Appld. Mech.*, Vol. 4, No. 1, March 1937.

The maximum depression occurs in line with the load and its value is given by

$$y_0 = \frac{P}{2}\,\frac{\beta}{U} \qquad \text{(B-24)}$$

$$= P\sqrt[4]{64\,EIU^3} \qquad \text{(B-25)}$$

$$= 10.7\,P\sqrt[4]{IU^3} \text{ inches} \qquad \text{(B-26)}$$

The maximum moment occurs at the same point and its value is given by

$$M_0 = \frac{P}{4}\,\frac{1}{\beta} = P\sqrt[4]{\frac{EI}{64\,U}} \qquad \text{(B-27) (B-28)}$$

$$= 0.318\,P.\,X_1 \text{ tons-inches} \qquad \text{(B-29)}$$

$X_1$ is the abscissa of the point at which the moment is 0 :

$$X_1 = \frac{\pi}{4}\,\frac{1}{\beta} = \frac{\pi}{4}\sqrt[4]{4\,\frac{EI}{U}} \qquad \text{(B-20)}$$

$$= 82.2\sqrt[4]{\frac{I}{U}} \text{ inches} \qquad \text{(B-21)}$$

There is a point of inflexion where the depression as well as the pressure under the rail are 0 at the abcissa $X_2$

$$X_2 = \frac{3}{4}\,\pi\,\frac{1}{\beta} = \frac{3}{4}\,\pi\sqrt[4]{\frac{4EI}{U}} \qquad \text{(B-22)}$$

$$\therefore X_2 = 3\,X_1 \qquad \text{(B-23)}$$

The maximum linary reaction is equal to

$$p_0 = P\sqrt[4]{\frac{U}{64\,EI}} \qquad \text{(B-30)}$$

$$= 0.005\,P\sqrt[4]{\frac{U}{I}} \text{ lbs per inch} \qquad \text{(B-31)}$$

The reaction of a sleeper on the rail has an approximate value

$$q = 0.005\,P \cdot s \cdot \sqrt[4]{\frac{U}{I}} \text{ lbs} \qquad \text{(B-32)}$$

($s$, spacing of sleepers).

The tension to the extension in the rail is given by

$$f_0 = \frac{M_0}{Z} \qquad \text{(B-33)}$$

$$= 26.14\,\frac{P}{Z}\sqrt[4]{\frac{I}{U}} \text{ tons per sq. inches} \qquad \text{(B-34)}$$

(Z, modulus of the rail section),

and the maximum shear force given by the third derivative of the elasticity equals

$$EI\,\frac{d^3y}{dx^3} = -\frac{P}{2} \qquad \text{(B-35)}$$

**The combined effects of several loads.**

Setting out to an enlarged scale the useful part of the curves representing the bending moment and the depression of the track and joining thereto a diagram of the relative abcissae that is to say of the ratios

$$\frac{X}{X_1},$$

enables us to read the relative value of the bending moment at a given distance from the load P. This relative value is added to the maximum moment and is expressed by a coefficient affecting the load P.

In the case of two wheels placed at a known distance, the curve of the moment relating to each can be traced and the ordinates of the two curves can be added together algebraically. It is also possible, if only the maximum moments in line with the wheels be calculated, to determine as explained above the relative values of the moment of each wheel about the vertical through the other and then made the sum of the real load of one wheel and of the influence of the other.

The combined effect of two adjacent wheels on the depression of the track could be calculated in the same manner.

In the case of any particular arrangement of wheels corresponding to one given type

of locomotive, the influence of each wheel on each of the other wheels about their vertical axis will be calculated to begin with and the summations of the real loads plus the influences will be made afterwards.

It will be noted that $X_1$ is constant for a given track.

As regards the coefficient U, its value depends upon various factors. For well ballasted track and with rails of 60 to 80 lbs per yard, its value can be taken as 1 000 pounds per inch of length for a sinking of 1 inch. Its influence is limited by the fact that it only comes into effect under the power $\frac{1}{4}$.

**Maximum permissible wheel loading.**

With a steel rail of 44 to 55 tons breaking stress and 24 to 27 tons elastic limit, and taking 75 % of the latter as the practical limit, that is 18 tons per sq. in., and making $U = 1\,000$ and $f_0 = 18$ in the equation giving $f_0$,

$$f_0 = \frac{26.14}{5.63} \cdot P \cdot \frac{\sqrt[4]{I}}{Z} \qquad \text{(C-1)}$$

$$\therefore 18 = 4.64 \cdot P \cdot \frac{\sqrt[4]{I}}{Z} \qquad \text{(C-2)}$$

$$P = 3.88 \cdot \frac{Z}{\sqrt[4]{I}} \text{ tons} \qquad \text{(C-3)}$$

Tests carried out in America have shown that when running the wheel load can exceed the normal load by 20 to 50 %. Taking the mean i.e. 33 % only three quarters of the load calculated above can be allowed, that is

$$P = 2.91 \frac{Z}{\sqrt[4]{I}} \text{ tons} \qquad \text{(C-4)}$$

Such is the virtual load of isolated wheel with no speed limitation on new rails.

In order to take into account rail wear the convention is that they are taken out of service when worn down by 10 % from their original height, and this leads to taking as virtual load nine tenths of P or

$$Q = 2.62 \frac{Z}{\sqrt[4]{I}} \text{ tons} \qquad \text{(C-7)}$$

It should be pointed out that for sections of rails which are alike geometrically the ratio

$$\frac{Z}{\sqrt[4]{I}}$$

is proportional to the weight per unit of length. Calculations made on flat bottomed to B.S. Specification (English standards) show that we can take

$$Q = 0.15 \text{ W tons} \qquad \text{(C-8)}$$

(W, tons per yard),

$$336 \text{ W pounds} \qquad \text{(C-9)}$$

Various factors lead to a reduction in this virtual load when dealing with a guiding wheel or a wheel which deforms the track from its initial level and to taking in this case

$$Q_1 = 0.9 \quad Q = 0.135 \text{ W tons} \qquad \text{(C-13)}$$

This is the virtual value that is to be compared with the real loads as affected by the action of the adjacent wheels and after having taken into account the following elements.

**Influence of the speed.**

Measurements recorded during trials justify the adoption for expressing the impact factor K of the Indian Government Railways formula

$$K = \frac{V}{3\sqrt{U}} \qquad \text{(E-9)}$$

and the speed factor is then given by

$$1 + K \pm 1 + \frac{V}{3\sqrt{U}} \qquad \text{(E-10)}$$

Taking U = 1 000 (standard track) the equivalent static wheel load on standard gauge track is given by

$$\varepsilon_0 = \frac{Q}{1 + \frac{V}{95}} \text{ tons (maximum)} \qquad \text{(E-11)}$$

**Other factors.**

Amongst other factors affecting the wheel loads on the rails the hammer blow (inertia force of the masses balancing the alternating parts), and the increase due to the tractive effort (oblique force of the connecting rod or the action of an electric traction motor on the driving axle) must in particular be taken into account.

As regards the *hammer blow*, it differs according as the balancing is done statically or dynamically (taking into account the fact that the masses are in different planes). The difference, in increase when the balancing is dynamic can be considered as engulfed in the speed factor. The action of balancing masses is proportional to the square of the speed and is easily calculated. In what follows the hammer blow factor will be designated by the letter H.

*The increase in load due to the traction* in the case of steam locomotives is due to the obliquity of the connecting rod. The vertical component of the load on the connecting rod loads the driving axle directly, whilst the pressure on the cross-head guides acts on the spring borne mass. In all, this additional loading at very low speeds can be taken as

$$T = \frac{2}{\pi} \cdot N \text{ tons} \qquad \text{(F-6)}$$

the symbol N representing the maximum value of the vertical component of the load on the connecting rod. As the speed increases, it diminishes progressively to half of its value at the speed of 7 revolutions per second.

In the case of the electric traction motors, with nose suspended motors there is an alteration of the loads on the wheels depending upon the position relatively to the axle (motor in front of or behind the axle). A statical investigation of the forces in play enables the alteration on each of the axles to be calculated.

With the motors carries on the frame and drive by quill, there is no increase due to the traction.

**Signification and calculation of the index.**

The index-number proposed by the author applies to a given rail section and is the ratio of the tensile stress in the rail produced by the heaviest wheel loading equivalent for a given group to that produced by the isolated virtual wheel load permitted on the rail for the conditions of standard gauge track.

The index C is therefore the ratio of the two quantities : $\varepsilon$, equivalent wheel load, and Q virtual load of isolated wheel :

$$C = \frac{\varepsilon}{Q} . \qquad (17)$$

The quantity Q has been defined above. As to the load $\varepsilon$, it is ascertained in the following way.

The dynamic factors due to the hammer blow and to the traction ought to be added to the real load P so that the virtual wheel load at the speed 0 + is given by

$$J_0 = (P + T) \text{ tons} \qquad (11)$$

and at the service speed allowed

$$J_s = [P (1 + K) + H + T] \text{ tons} \qquad (12)$$

This virtual load ought to be adjusted by the coefficient F expressing the lightening due to the adjacent wheels. Consequently, the equivalent wheel load of a vehicle under the conditions allowed for standard track is

at zero speed

$$\varepsilon_0 \quad J_0 \cdot F$$

$$\varepsilon_0 = (P + T) F \text{ tons} \qquad (13) \text{ and } (14)$$

and at the permitted service speed :

$$\varepsilon_s = J_s \cdot F \quad . \quad . \quad .

Naturally, the ratio C should be below, or at the maximum equal to unity, because at this value there is an actual fatigue stress in the rail reaching the maximum value allowable.

The author then proposes, in place of specifying the maximum axle load allowed, to specify the weight of the rail and the maximum value permitted for the index-number. This can be expressed as a function of several speeds.

*(a)* immediately after starting, that is at zero speed,

*(b)* at the booked service speed,

*(c)* the speed at which the index-number becomes equal to unity.

The maximum admitted for the value of of the index being unity in the conditions of standard track and for a given rail, if the modulus of the track has another value, the value admitted for the index will be:

$$C = \sqrt[4]{\frac{U_p}{1\,000}} \qquad (18)$$

In the same way, the equivalent wheel load follows the new value of the modulus of the track:

$$\varepsilon_0^p = \varepsilon_0 \sqrt[4]{\frac{U_p}{1\,000}} \text{ tons} \qquad (19)$$

and if at the same time the weight of rail used is different the equivalent wheel load becomes

$$\varepsilon_0^p = \varepsilon_0 \frac{N_1 \cdot Z_p}{N_p \cdot Z_1} \qquad (20)$$

The maximum allowed speed will be attained when $\varepsilon_s$ will be equal to Q, on standard gauge track. It is given by

$$1 = \frac{Q - \varepsilon_0}{\varepsilon_1 - \varepsilon_0} \cdot V \cdot \text{miles per hour} \qquad (21)$$

If the track modulus is different, or if at the same time the rail is also to another profile, the loads $\varepsilon_0$ and $\varepsilon_s$ have to be modified as indicated above.

**Example of an application.**

The sheets of calculations reproduced here (forms I*a* and I*b*), selected from the seven cases dealt with, relate to the type 4-6-2 locomotive of the PR class running over track laid with 60 lb. rails.

These show that at a very low speed, theoretically zero, the index-number :

$$C = \frac{\varepsilon_0}{Q} = \frac{5.56}{9.00} = 0.65.$$

At a speed of 45 m.p.h., it equals 0.91. Moreover, the maximum allowable speed in order not to exceed the stress in the rail equals 55 m.p.h.

**Determination of the modulus of elasticity of the formation of the track.**

In an appendix the author shows how the factor U can be calculated. By placing a locomotive of known weight on the track and measuring the depression of all the sleepers, which have undergone any change in level, the factor looked for is found by dividing the total weight on a rail by the product of the sum of the depressions and of the spacing of the sleepers. If the locomotive weight 60 tons of 2 240 pounds, the sum of the depressions being equal to 2.4 inches and the spacing equal to 30 inches, the value will be

$$U = \frac{30 \times 2\,240}{2.4 \times 30} = 934 \text{ lbs}$$

per inch for a depression of 1 in.

The effect of the rail joints may be avoided by placing at the middle of a length of rail one of the bogies of a coach with two bogies sufficiently widely spaced.

**Notes on the track.**

In another appendix, the author sets out his views on the factors which affect the solidity of the track.

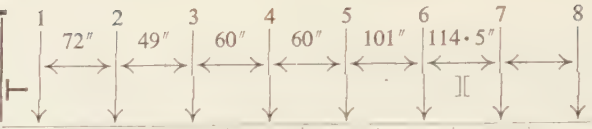
The depth of the ballast is very important and an increase in it can have a greater effect than the use of longer sleepers. The criterium is the distribution of the pressure

FORM Ia.

**Locomotive rail-stress index**
**(at speed 0 +)**

Class PR  Traction Steam

Type 4 — 6 — 2 . . . . .




| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Weel No |
|---|---|---|---|---|---|---|---|---|---|
| Stastic load = P . . . . . | 2·92 | 2·92 | 7·00 | 7·00 | 7·00 | 5·15 | 5·01 | | tons |
| Traction augment = $T_0$. . . | | | | 1·65 | | | | | » |
| Virtual wheel load = $J_0$ . . . | 2·92 | 2·92 | 7·00 | 8·65 | 7·00 | 5·15 | 5·01 | | » |
| Using master diagram and $X_1$ = 29·4 in. (for U = 1 000) | | | | | | | | | |
| Effect of 1 . . . . . | 2·92 | —·55 | —·10 | | | | | | tons |
| » 2 . . . . . | —·55 | 2·92 | —·57 | —·19 | | | | | » |
| » 3 . . . . . | —·24 | —1·38 | 7·00 | —1·45 | —·26 | | | | » |
| » 4 . . . . . | | —·56 | —1·80 | 8·65 | —1·80 | | | | » |
| » 5 . . . . . | | | —·26 | —1·45 | 7·00 | —·64 | | | » |
| » 6 . . . . . | | | | | —·47 | 5·15 | — | | » |
| » 7 . . . . . | | | | | | —·25 | 5·01 | | » |
| » 8 . . . . . | | | | | | | | | » |
| Equiv. : wheel load = $\varepsilon_0$ . . | 2·13 | 0·43 | 4·27 | 5·56 | 4·47 | 4·26 | — | | » |
| Equiv. : effect for U = 1 000 $\varepsilon_0^p = \varepsilon_0 \sqrt[4]{1\,000/1\,000}$ | | | | | 4·47 | | | | » |

*Track data :*

Rails (W) 60 lb./yd.

I = 16·26 in⁴  Z = 7·04 in³

U = 1 000 lb./in./in.

$X_p$ = 29·4 inches

Q = 0·15 W = 9·0 tons

$Q_1$ = 0·135 W = — tons

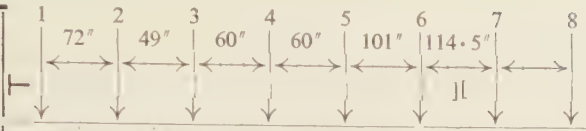
Rail stress index : C = $\varepsilon_0/Q$ = 5·56/9·0
(Max. of $\varepsilon_0/Q$ or $\varepsilon_0^1/Q_1$)

= 0·65 at 0 + on 60 lb. rails

FORM 1*b*.

**Locomotive rail-stress index**
**(at rated service speed)**

Class PR Traction steam Service speed 45 m.p.h.




| Type 4 — 6 — 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Wheel No |
|---|---|---|---|---|---|---|---|---|---|
| Static Load = P | 2·92 | 2·92 | 7·00 | 7·00 | 7·00 | 5·15 | 5·01 | | tons |
| Load at speed. = P (1 + K) | 4·31 | 4·31 | 10·30 | 10·30 | 10·30 | 7·60 | 7·40 | | » |
| Traction augment = $T_s$ | | | | 0·97 | | | | | » |
| Hammer blow = H | | | 1·68 | 1·68 | 1·68 | | | | |
| Virtual wheel load = $J_s$ | 4·31 | 4·31 | 11·98 | 12·95 | 11·98 | 7·60 | 7·40 | | » |
| Using master diagram and $X_1$ = 29·4 in. (for U = 1 000) | | | | | | | | | |
| Effect of 1 | 4·31 | —·81 | —·15 | | | | | | tons |
| » 2 | —·81 | 4·31 | —·85 | —·29 | | | | | » |
| » 3 | —·42 | —2·36 | 11·98 | —2·50 | —·42 | | | | » |
| » 4 | | —·84 | —2·69 | 12·95 | —2·69 | | | | » |
| » 5 | | | —·42 | —2·50 | 11·98 | —1·10 | | | » |
| » 6 | | | | | —·70 | 7·60 | — | | » |
| » 7 | | | | | | —·40 | 7·40 | | » |
| » 8 | | | | | | | | | » |
| Equiv. : wheel load = $\varepsilon_s$ | 3·08 | 0·30 | 7·87 | 7·66 | 8·17 | 6·10 | — | | » |
| Equiv. : effect for U = 1 000 $\varepsilon^p_s = \varepsilon_s \sqrt[4]{1\,000/1\,000}$ | | | | | 8·17 | | | | » |

*Track data* :

Rails (W) 60 lb./yd. I = 16·26 in$^4$ Z = 7·04 in$^3$

U = 1 000 lb./in./in. $X_p$ = 29·4 inches

Q = 0·15 W = 9·0 tons $Q_1$ = 0·135 W = — tons

Rail-stress index : C = $\varepsilon_s/Q$ = 8·17/9·0
(max. of $\varepsilon_s/Q$ or $\varepsilon^1_s/Q_1$)
= 0·91 at 45 m.p.h. on 60 lb. rails

Max. permissible value of C (for U = 1 000) = $\sqrt[4]{1\,000/1\,000}$ = 1·0

For U = 1 000, C = 1 at $[(Q - \varepsilon_0)/(\varepsilon_s - \varepsilon_0)]$ V m.p.h.
= [(9·0 — 4·47)/(8·17 — 4·47)] × 45 m.p.h.
= 55 m.p.h.

For U = —, C = 1 at $[(Q - \varepsilon_0{}^p)/(\varepsilon^p{}_s - \varepsilon^p{}_0)]$ V m.p.h.
= [( — )/( — )] × m.p.h.
= m.p.h.

over the formation rather than the intensity of the pressure between sleeper and ballast. To increase the load carrying capacity of a track it is cheaper to reinforce the rails than to increase the number of sleepers.

With the extension of diesel electric traction with which 20 ton axle loads are sufficient, the question of the limitations in force on the bridges on the main line can be reviewed.

Finally, because of the repeated phenomena of bending caused by the succession of bogie wagons passing, it is better to transport a given traffic on a minimum number of axles loaded to the limit permitted for the rail in use than by lighter rolling stock involving a greater number of axles.

This paper was followed by a discussion during which various observations were made. The author replied, giving detailed explanations and additional information. We have made notes of a few points dealing with the constitution of the superstructure of the permanent way.

The effect of tamping is shown by two diagrams showing the depression of the sleepers and the track before and after tamping. The improvement after tamping is obvious, and it can also be seen how tamping helps the distribution over a greater number of sleepers.

Two other diagrams show the distribution of pressure in the ballast and the amount of pressure on the bed with various thicknesses of the layer of ballast. The advantage of increasing the thickness is appreciable, especially when the depth exceeds 10 inches.

For the 3 feet 6 in. track, the author considers that 6 ft. 6 in. sleepers are better than 7 ft. sleepers. This opinion seems to be confirmed by the diagram showing the distribution of pressure along a sleeper. As regards the section of sleepers, with approximately the same transversal area, a section of 8 by 5 inches seems to him better than 9 by 4 1/2, as the former ensures greater rigidity and improves the distribution of the pressure.

In view of the remark about the length of sleepers, the author suggests a modification to the plan of the standard track of the Western Australian Government Railways, which whilst conserving the same volume of ballast would increase the thickness under the lower portion of the sleepers to 8 inches instead of 6.

# MONTHLY BIBLIOGRAPHY OF RAILWAYS[1]

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Génie civil, nº 3346, 1er avril, p. 133.
COÜARD (A.). — **Le béton armé orthodoxe et ses anomalies.** (1 000 mots.)

**1953** **624** (42) & **691** (42)
Génie civil, nº 3347, 15 avril, p. 155.
Le **pont de chemin de fer en béton précontraint** de Rotherham, près de Sheffield (Grande-Bretagne). (300 mots & fig.)

## L'Ossature métallique. (Bruxelles.)

**1953** **62** (01 & **669**
L'Ossature métallique, février, p. 93.
BAES (L.). — Note complémentaire à la « Contribution à l'étude des critères de la **résistance statique des matériaux métalliques** ». (1 300 mots & fig.)

**1953** **624** .8 (73)
L'Ossature métallique, février, p. 96.
**Pont levant** sur le Harlem River, à New-York. (500 mots & fig.)

**1953** **624** .62 (43)
L'Ossature métallique, mars, p. 135.
**Reconstruction du pont sur le Rhin** à Dusseldorf-Neuss. (2 500 mots & fig.)

**1953** **624** (494)
L'Ossature métallique, mars, p. 161.
KOLLROSS (W.). — Le **déplacement du pont** de la gare sur l'Aar, à Olten (Suisse). (1 000 mots & fig.)

**1953** **624** .2 (493)
L'Ossature métallique, mars, p. 165.
VERWILST (Y.). — **Essais pulsatoires et essai statique à la rupture d'une importante poutre** de 14.50 m sur l'installation G.I.M.E.D. de l'Association des Industriels de Belgique (A.I.B.). (1 500 mots & fig.)

**1953** **625** .2 & **669** .1
L'Ossature métallique, mars, p. 170.
HERBIET (H.) & SCAILTEUR (C.). — L'**intérêt des aciers à haute résistance dans la construction du matériel roulant.** (2 000 mots & fig.)

## Revue de l'Aluminium. (Paris.)

**1953** **621** .392 & **669** .71
Revue de l'Aluminium, février, p. 67.
GUIGNARD (Ch.). — Le **soudage par résistance des métaux légers.** (3e Partie). (2 000 mots & fig.)

**1953** **625** .13 & **669** .71
Revue de l'Aluminium, février, p. 80.
Des **coffrages en alliage léger** pour le bétonnage des galeries et tunnels. (500 mots & fig.)

## Revue Générale des Chemins de fer. (Paris.)

**1953** **621** .335 (44)
Revue Générale des Chemins de fer, mars, p. 109.
BLONDET (M.). — La **locomotive CC 6052 à moteurs directs 50 Hz** de la S.N.C.F. (4 000 mots & fig.)

**1953** **385** .3 (44)
Revue Générale des Chemins de fer, mars, p. 123.
MARCY. — L'**avenant du 10 juillet 1952** à la Convention du 31 août 1937 dans le cadre des grands **problèmes de gestion du Chemin de fer.** (20 000 mots.)

**1953** **625** .1 (44) & **656** .21 (44)
Revue Générale des Chemins de fer, mars, p. 163.
**Reconstructions** inachevées à la S.N.C.F. (2 000 mots & fig.)

**1953** **385** .113 (44)
Revue Générale des Chemins de fer, mars, p. 179.
L'**exploitation de la S.N.C.F.** en 1952. (Résultats provisoires). (1 000 mots & tableau.)

**1953** **656** (44)
Revue Générale des Chemins de fer, mars, p. 182.
La **coordination rail et route** pour les transports publics de marchandises à grande distance, en France. (1 000 mots.)

## Revue Générale de Mécanique. (Paris.)

**1953** **62** (01
Revue Générale de Mécanique, janvier, p. 1.
PROT (M.). — **Essais de fatigue sous charge progressive.** Etude de la dispersion des résultats. (1 000 mots & tableaux.)

**1953** **625** .28
Revue Générale de Mécanique, janvier, p. 11.
**Le Matériel ferroviaire et l'esthétique.** (1 500 mots & fig.)

## Revue de la Soudure. (Bruxelles.)

**1952** **621** .392 (06

Revue de la Soudure, nº 4, p. 185.

Le **Congrès de Soudure** de Göteborg-Suède. (6 000 mots & fig.)

## Revue technique Sulzer. (Winterthur.)

**1952** **656** .211.7

Revue technique Sulzer, nº 2, p. 1.

STEIGER (J.). — Les **ferry-boats** équipés avec des moteurs Diesel-Sulzer. (1 200 mots & fig.)

## Revue des Transports et des Communications. (Lake Success.)

**1951** **656** (73)

Revue des Transports et des Communications, nº 4, octobre-décembre, p. 47.

FREDERICK (J.H.). — L'évolution de la **réglementation des transports** aux Etats-Unis d'Amérique. (7 000 mots.)

## Revue de l'Union internationale des Transports Publics. (Bruxelles.)

**1952** **629** .113.5 (493)

Revue de l'Union intern. des Transports publics, nº 3, p. 141.

DAUBRESSE (J.). — Les **nouveaux types d'autobus** utilisés par la Société Nationale des Chemins de fer Vicinaux. (3 500 mots & fig.)

**1952** **625** .42 (485)

Revue de l'Union intern. des Transports publics, nº 3, p. 189.

SAMUELSON (S.). — Der **Ausbau der öffentlichen Verkehrsmittel** in Gross-Stockholm. (4 000 mots & fig.)

## Les Transports publics. (Lausanne.)

**1953** **656** (493)

Les Transports publics, février, p. 10.

PAQUAY (A.). — La **coordination des transports** en Belgique. (1 000 mots.)

**1953** **656** (44)

Les Transports publics, mars, p. 6.

La **concurrence** faite à la S.N.C.F. par les transporteurs routiers. (800 mots.)

## Travaux. (Paris.)

**1953** **62** (01 & **691**

Travaux, mars, p. 189; avril, p. 259; mai, p. 285.

DURIEZ (M.). — **Action de l'eau de mer et des eaux agressives sur les chaux et ciments.** Comportement des mortiers et bétons hydrauliques. — **Cas particulier du béton armé.** Causes et effets. — Prévention et remèdes. (14 000 mots & fig.)

**1953** **62** (01

Travaux, mars, p. 216.

VALLETTE (R.). — **Contraintes-Déformations.** Le cisaillement et le glissement n'existent pas. (500 mots & fig.)

**1953** **62** (01

Travaux, mars, p. 227.

MALLET (Ch.). — La **théorie de la déformation permanente et de la rupture.** (1 000 mots.)

## La Vie du Rail. (Paris.)

**1953** **656** .211.5 (44)

La Vie du Rail, 16 février, p. 6.

En période de pointe, le **nouveau Central-Location** de Paris-Lyon satisfait une commande toutes les vingt secondes. (800 mots & fig.)

# In German.

## Der Eisenbahningenieur. (Frankfurt a. Main.)

**1953** **613** .66

Der Eisenbahningenieur, März, S. 53.

HENRICI. — Der **elektrische Unfall** und die Verträglichkeit des elektrischen Stromes für den Menschen. (1 500 Wörter & Tafel.)

**1953** **625** .143.4

Der Eisenbahningenieur, März, S. 55.

CLEMENS (O.). — Der **kraftschlüssige Schienenstoss für Holz- und Stahlbetonschwellen.** (1 000 Wörter & Abb.).

**1953** **621** .335 & **625** .28

Der Eisenbahningenieur, März, S. 57.

KÖHLER (H.). — Ein Beitrag zur **Fahrdynamik elektrischer Triebfahrzeuge.** (5 000 Wörter & Abb.)

**1953** **621** .335 (43)

Der Eisenbahningenieur, März, S. 63.

FRIES (R.). — Einsatz von **Speicherkleinloks** und Kleinlokladeanlagen für 16 2/3 Hertz im Bezirk der ED Nürnberg. (1 000 Wörter & Abb.)

**1953** **625** .113

Der Eisenbahningenieur, März, S. 66; Mai, S. 113.

JIRA (F.). — Das **Krümmungsbildverfahren.** (5 000 Wörter & Abb.)

## E.T.R. Eisenbahntechnische Rundschau. (Köln-Darmstadt.)

**1953** **621** .138

Eisenbahntechnische Rundschau, März, S. 83.

RABUS (J.). — Grundzüge der **Erhaltung von Lokomotiven.** (3 500 Wörter & Abb.)

**1953** **625** .26

Eisenbahntechnische Rundschau, März, S. 90.

GROTRIAN (O.). — Grundsätze für die **Erhaltung der Wagen** in den Eisenbahn-Ausbesserungswerken. (3 000 Wörter & Abb.)

1953 625 .26 (43)
nbahntechnische Rundschau, März, S. 96.
IENS (G.). — Die **Ausbesserung von Fahrzeugen** Deutschen Bundesbahn in der Industrie nach dem ge. (2 000 Wörter.)

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1953 621 .9 (43) & 625 .26 (43)
nbahntechnische Rundschau, März, S. 100.
CHÖFFEL (E.). — **Hartmetallwerkzeuge in den nbahnwerkstätten.** (2 000 Wörter & Abb.)

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1953 625 .235
nbahntechnische Rundschau, März, S. 104.
EHM (M.). — Das **Anstrichproblem** im Werkendienst. (5 000 Wörter & Abb.)

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1953 621 .392 & 625 .26
nbahntechnische Rundschau, März, S. 116.
TIELER (C.). — Die **Schweisstechnik** in der Fahrgerhaltung. (1 500 Wörter & Abb.)

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1953 625 .26
nbahntechnische Rundschau, März, S. 120.
MARXER (M.).— **Wirtschafts- und Betriebsprüfungen** Eisenbahn-Ausbesserungswerken. (3 500 Wörter & .)

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1953 385 .1 & 625 .26
nbahntechnische Rundschau, März, S. 126.
RAMBERG (U.). — Entwicklung der **Betriebsechnung in den Eisenbahn-Ausbesserungswerken.** (2 500 rter & Abb.)

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1953 625 .26 (43)
nbahntechnische Rundschau, März, S. 131.
LS (H.). — **Modellbetrieb im Werkstättendienst.** 00 Wörter & Abb.)

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## Elektrische Bahnen. (München.)

1953 621 .332
ktrische Bahnen, Februar, S. 25.
ÜBERKRÜB (M.). — Berechnungsverfahren für die **mittlung von Höchstspannweiten für Fahrleitungen.** 000 Wörter & Abb.)

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1953 621 .333
ktrische Bahnen, Februar, S. 32.
TÖFFLINGER (K.). — Der Bürstenkontakt beim **echselstrombahnmotor.** (2 500 Wörter & Abb.)

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1953 621 .336
ktrische Bahnen, Februar, S. 36.
GÖTTINGER (J.). — Der **Scherenstromabnehmer für he Fahrgeschwindigkeiten.** (6 000 Wörter & Abb.)

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1953 625 .14 (01 & 625 .2 (01
ektrische Bahnen, März, S. 49.
SCHWEND (F.). — Die **Reibung zwischen Rad und hiene.** (5 000 Wörter & Abb.)

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1953 621 .336
ektrische Bahnen, März, S. 58.
SCHWAIGERT (E.). — Über die **Abnützung des romabnehmer-Schleifstückes.** (1 200 Wörter & Abb.)

1953 625 .21
Elektrische Bahnen, März, S. 60.
LEVEN (W.). — Kennzeichnung der **Laufeigenschaften von Schienenfahrzeugen.** (4 500 Wörter & Abb.)

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## Glasers Annalen. (Berlin.)

1953 621 .134.2
Glasers Annalen, Februar, S. 25.
WEIRICH (H.) & WISSMANN (W.). — **Genaue Ermittlung der Massendrücke in Lokomotiv-Steuerungsgetrieben.** *(Berichtigung zu diesem Aufsatz, Nr. 4, April 1953, S. 93.)* (5 000 Wörter, Tabellen & Abb.)

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1953 621 .134
Glasers Annalen, März, S. 47.
POSTUPALSKY (N.). — Der **günstigste Dampfverbrauch der Lokomotivmaschine.** (3 000 Wörter & Abb.)

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1953 536
Glasers Annalen, März, S. 52.
POLOCK (B.). — **Luft und Wasserdampf als Wärmeträger im Kreislaufprozess.** (2 000 Wörter & Abb.)

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## Signal und Draht. (Frankfurt a. Main.)

1953 656 .257 (436)
Signal und Draht, März, S. 37.
KASBERGER (K.). — Das **elektrische Mittelstellwerk** der Österreichischen Bundesbahnen. (1 700 Wörter & Abb.)

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1953 656 .255
Signal und Draht, März, S. 40.
GRANDRATH (F.). & SCHIEREN (B.). — **Bewegbare Hilfsbetriebsstelle für zeit- oder wechselweise ein- und zweigleisigen Betrieb** auf zweigleisigen Bahnen. (2 000 Wörter & Abb.)

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1953 656 .25
Signal und Draht, März, S. 45.
SCHMITZ (W.). — **Installations-Selbstschalter** oder **Sicherungen** in Eisenbahnsignalanlagen? (2 000 Wörter & Abb.)

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## Verkehr. (Wien.)

1953 385 (09 (469)
Verkehr, 7. März, S. 301.
KÜBLER (E.). — **Portugals Eisenbahnen.** (1 000 Wörter.)

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# In English.

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## The Engineer. (London.)

1953 625 .19 (42)
The Engineer, March 20, p. 414.
**Soil failures in a railway cutting** (II). (2 200 words & figs.)

**1953** **625** .242 (42)
The Engineer, March 20, p. 424.
**Standard wagons for British Railways.** (600 words & fig.)

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**1953** **624** .5 (42)
The Engineer, March 27, p. 469.
**The erection of a railway bridge.** (700 words & fig.)

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**1953** **621** .131 (42)
The Engineer, April 3, p. 487.
TUPLIN (W.A.). — **Some locomotive dimensions compared.** (1 900 words & fig.)

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## Engineering. (London.)

**1953** **621** .438 (42)
Engineering, February 27, p. 276.
DYMOND (A.W.J.). — **Operating experiences with two gas-turbine locomotives** *(concluded)*. (3 000 words.)

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**1953** **621** .134.3 (42)
Engineering, March 6, p. 299.
**The « R.R. » poppet-valve gear for locomotives.** (1 200 words & figs.)

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**1953** **621** .392 (42)
Engineering, March 6, p. 315.
TAYLOR (R.W.). — **The scope of stud-welding.** (1 900 words & figs.)

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**1953** **625** .26 (42)
Engineering, March 13, p. 331.
**Carriage cleaning and maintenance depot.** (1 800 words & figs.)

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**1953** **625** .242 (42)
Engineering, March 20, p. 380.
**Iron-ore and covered hopper wagons for British Railways,** (500 words & figs.)

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**1953** **656** .212.6 (42)
Engineering, March 27, p. 409.
**Automatic tippler for railway wagons.** (800 words & figs.)

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**1953** **625** .25 (42)
Engineering, April 3, p. 419.
WALL (T.F.). — **Electric-traction braking.** III. (2 000 words & figs.)

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**1953** **625** .1 (42)
Engineering, April 10, p. 456; April 17, p. 487.
**Embankment slips in railway cutting.** (4 800 words & figs.)

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## The English Electric Journal. (Stafford.)

**1953** **621** .335 (46)
The English Electric Journal, March, p. 3.
**3 600 HP, 3 000 Volts direct current locomotives for the Spanish National Railways.** (3 600 words & figs.)

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## The Journal of the Institute of Transport. (London.)

**1953** **656**
The Journal of the Institute of Transport, March, p. 73.
ARMAND (L.). — **Fundamental techniques in transport and their recent evolution.** (4 000 words.)

## Journal, The Institution of Locomotive Engineers. (London.)

**1952** **621** .13 (42) & **621** .133.1 (42)
Journal, The Institution of Locomotive Engineers, Vol. 42 (Part No. 5), p. 390.
JARVIS (R.G.). — **The railways and coal.** (35 pages.)

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**1952** **621** .132 & **621** .133.1
Journal, The Institution of Locomotive Engineers, Vol. 42 (Part No. 5), p. 425.
IKESON (W.C.). — **Development of the oil-fired locomotive.** (91 pages with figs.)

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## Proceedings, The Institution of Mechanical Engineers. (London.)

**1952** **669**
Proceedings, The Institution of Mechanical Engineers, Vol. 166, No. 4, p. 413.
MOTT (N.F.). — **The mechanism of work-hardening of metals.** (3 600 words & figs.)

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## The Locomotive. (London.)

**1953** **621** .132.6 (68)
The Locomotive, March, p. 32.
**0-8-0 shunting locos, class « S 2 », South African Railways.** (800 words & figs.)

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**1953** **621** .132.1 (54)
The Locomotive, April, p. 46.
**100 years of locos for India.** (4 800 words & figs.)

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**1953** **621** .134.2 (42)
The Locomotive, April, p. 54.
**R. R. poppet type valve gear.** (900 words & figs.)

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## Mechanical Engineering. (New York.)

**1953** **621** & **656** .2
Mechanical Engineering, April, p. 291.
**Progress in railway mechanical engineering 1951-1952.** (5 400 words & figs.)

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## Modern Transport. (London.)

**1953** **621** .132.1 (42)
Modern Transport, February 14, p. 15.
**New standard tender locomotive.** British Railways, Class « 2 », 2-6-0 type. (1 200 words, tables & figs.)

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**1953** **656** .1 (42) & **656** .2 (42)
Modern Transport, February 21, p. 5.
**Transport in Leinster and Ulster.** Road and rail facilities. IV *(to be continued)*. (1 200 words & figs.)

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**1953** **621** .132.1 (42) & **621** .134.3 (42)
Modern Transport, February 21, p. 13.
**Extended trial of new valve gear.** (900 words & figs.)

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**1953** **385** (09 (54)
Modern Transport, March 7, p. 3.
**Centenary of Indian Railways.** (1 500 words & figs.)

**1953** **625** .244
Modern Transport, March 7, p. 6; April 4, p. 5.
PURDOM (W.). — **International refrigerated transport.** (2 200 words & fig.)

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## The Oil Engine and Gas Turbine. (London.)

**1953** **621** 431.72 (73)
The Oil Engine and Gas Turbine, April, p. 441.
**Locomotive with one 2 400 B. H. P. engine.** (800 words & figs.)

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## The Overseas Engineer. (London.)

**1953** **625** .212 (42)
The Overseas Engineer, April, p. 319.
**Servicing rail-car wheel assemblies.** (1 400 words & figs.)

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## Railway Age. (New York.)

**1953** **625** .232 (73)
Railway Age, February 9, p. 77.
**New cars for the new « Zephyrs ».** (3 200 words, tables & figs.)

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**1953** **625** .214 (73)
Railway Age, February 9, p. 84.
**How hot boxes can stop trains automatically.** (800 words & figs.)

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**1953** **621** .438 (73)
Railway Age, February 16, p. 39.
**How gas turbines perform on the Union Pacific.** (3 000 words & figs.)

---

**1953** **656** .212 (73) & **656** .254 (73)
Railway Age, February 23, p. 47.
**Frisco's radio-loudspeaker system** allows... faster car inspection. (800 words & figs.)

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**1953** **656** .212 (73)
Railway Age, March 2, p. 18.
**Wheel checker gets results.** (300 words & figs.)

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**1953** **625** .242 (73)
Railway Age, March 9, p. 119.
Pullman-standard designs **all-welded covered hopper.** (1 600 words & figs.)

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**1953** **625** .214 (73)
Railway Age, March 23, p. 65.
LAUDIG (J.J.). — **Hot-box research results...** in the iron-back journal bearing. (3 000 words & fig.)

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**1953** **621** .431 .72 (73)
Railway Age, March 23, p. 70.
User's figures show **Diesel cars opening new era.** (600 words & figs.)

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**1953** **656** .2 (73)
Railway Age, March 23, p. 76.
BINGHAM (S.H.). — **Toward the automatic railroad.** (1 000 words & fig.)

## The Railway Gazette. (London.)

**1953** **385** (064 (54)
The Railway Gazette, March 13, p. 290.
**Indian Railways Centenary Exhibition.** (1 200 words.)

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**1953** **621** .134.5 (42)
The Railway Gazette, March 13, p. 292.
**Lubrication of steam locomotives.** (300 words & fig.)

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**1953** **625** .26 (42)
The Railway Gazette, March 13, p. 294.
**New carriage shed at Willesden, L.M.R.** (2 000 words & figs.)

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**1953** **621** .134.2 (42)
The Railway Gazette, March 20, p. 319.
**Rotary valve gear on L. M. R. locomotives.** (2 000 words & figs.)

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**1953** **621** .33 (492) & **656** .222.1 (492)
The Railway Gazette, March 20, p. 323.
SEMMENS (P.W.B.). — **Dutch electric train and locomotive performance.** (400 words & figs.)

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**1953** **621** .33 (675)
The Railway Gazette, March 20, p. 324; April 17, p. 452.
**Equipment for Belgian Congo electrification.** (3 100 words & figs.)

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**1953** **385**. (09 (54)
The Railway Gazette, March 20, p. 327.
BADHWAR (F.C.). — **Indian Railways — 1853-1953.** (4 000 words & figs.)

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**1953** **621** .132.1 (54)
The Railway Gazette, March 20, p. 336.
**Indian locomotive development and practice.** (1 500 words & figs.)

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**1953** **625** .2 (54)
The Railway Gazette, March 20, p. 339.
**Rolling stock design in India.** (800 words & figs.)

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## Diesel Railway Traction. (London.)

**1953** **621** .431.72 (73)
Diesel Railway Traction, April, p. 77.
HAMILTON (W.S.H.). — **N.Y.C. three-power locomotives.** (1 800 words & figs.)

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**1953** **621** .431.72 (54)
Diesel Railway Traction, April, p. 85.
**Diesel development in India and Pakistan.** (2 000 words & figs.)

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## Railway Locomotives and Cars. (New York.)

**1953** **621** .431.72 (73)
Railway Locomotives and Cars, March, p. 65.
**Air filter adhesive developed in laboratory and field tests.** (4 000 words & figs.)

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**1953** **625** .24 (73)
Railway Locomotives and Cars, March, p. 72.
**Six years' experience with an aluminium reefer...** (1 900 words & figs.)

**1953** **625 .24 (73)**
Railway Locomotives and Cars, March, p. 79.
PRICE (H.L.). — **Car design for reduced maintenance.** (2 400 words & figs.)

**1953** **621 .431.72 (73)**
Railway Locomotives and Cars, March, p. 82.
TALBOT (L.E.). — What is fuel for Diesel **locomotives.** (1 800 words.)

### Railway Magazine. (London.)

**1953** **385. (09 (54)**
Railway Magazine, April, p. 219.
**A century of railway development in India.** (2 100 words & figs.)

### Railway Track and Structures. (Chicago.)

**1953** **625 .17 (73)**
Railway Track and Structures, March, p. 264.
HOWARD (L.). — **Time studies a key to organization and a tool for increased output for M/W machines.** (2 000 words.)

## In Spanish.

### Ferrocarriles y Tranvias. (Madrid.)

**1953** **625 .62 (4)**
Ferrocarriles y Tranvias, marzo, p. 83.
HAMACHER (F.W.). — El **desarrollo de los tranvías** en Alemania y Europa Occidental. (4 000 palabras & fig.)

**1953** **625 .2**
Ferrocarriles y Tranvias, marzo, p. 95.
MAZARRASA QUIJANO (R.). — **Sigamos comparando.** (1 000 palabras.)

## In Italian.

### Giornale del Genio Civile. (Roma.)

**1953** **691 (45)**
Giornale del Genio Civile, gennaio-febbraio, p. 27.
CASTIGLIA (C.). — Il **nuovo regolamento del cemento armato.** Le proposte pubblicate dal Consiglio Nazionale delle Ricerche. (3 500 parole, tabelle & fig.)

### Ingegneria ferroviaria. (Roma.)

**1953** **624 .2 (45)**
Ingegneria ferroviaria, marzo, p. 171.
POLSONI (G.). — **Prove di carico del ricostruito viadotto** di Villetta. (2 000 parole & fig.)

**1953** **625 .1 (45)**
Ingegneria ferroviaria, marzo, p. 177.
VONA (G.). — La **ricostruzione della linea** Vairano-Isernia. (8 000 parole & fig.)

**1953** **385 .114 & 656 .2**
Ingegneria ferroviaria, marzo, p. 203.
PELLIS (P.). — **I costi di trasporto per ferrovia in funzione del sistema di trazione e delle caratteristiche della linea.** (3 500 parole & tabelle.)

**1953** **621 .33**
Ingegneria ferroviaria, marzo, p. 213.
MUSSO (G.). — Un relè per la selezione dei corti circuiti negli impianti di **trazione a corrente continua.** (2 500 parole & fig.)

### Rivista di Ingegneria. (Milano.)

**1953** **624 .2**
Rivista di Ingegneria, marzo, p. 268.
MATTIAZZO (F.). — Risultati di ulteriori prove sul solaio con **travi « Varese ».** (2 000 parole & fig.)

**1953** **621 .436 & 662**
Rivista di Ingegneria, marzo, p. 289.
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